

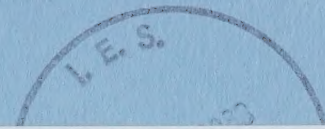


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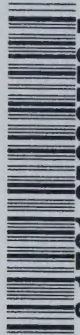
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Urban Air Quality Trends in Canada, 1970-79



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Surveillance
Report EPS 5-AP-81-14

Air Pollution Control Directorate
November 1981

Canada

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URBAN AIR QUALITY TRENDS IN CANADA, 1970-79

Data Analysis Division
Programs Branch
Air Pollution Control Directorate

Report EPS 5-AP-81-14
November 1981

Prepared for Environment Canada by S.C. Barton, Principal Scientist, Department of Environmental Chemistry, Ontario Research Foundation, under Department of Supply and Services Contract No. KE204-0-0569.

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NOTES TO READERS

1. Caution should be exercised by the reader when attempting to compare pollution levels in different cities. Monitoring data represent pollution levels measured at individual sampling sites within a city. The air quality measured at a specific site represents the condition of the air in the vicinity of that site and may not necessarily represent community-wide air quality. Community-wide comparisons should only be made using monitoring data from all available sampling stations within the city and interpreting these data on the basis of the specific sampling and location characteristics of the stations.

2. Because of instrumental and calibration difficulties encountered during the initial years of the National Air Pollution Surveillance (NAPS) monitoring program, data for the various pollutants are considered valid for only the periods shown below:

sulphur dioxide	-	1970 - present
nitrogen dioxide	-	1977 - present
carbon monoxide	-	1973 - present
ozone	-	1979
suspended particulates	-	1970 - present
lead	-	1970 - present
soiling index	-	1970 - present

(Valid data have been produced prior to these periods in certain cities and provinces. However, the data are considered valid nation-wide only during the periods shown.)

3. Detailed information on all NAPS stations can be found in the NAPS monthly and annual summaries.



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ABSTRACT

The air quality data presented in the monthly and annual summaries of the National Air Pollution Surveillance network between 1970 and 1979 are summarized and discussed in this report. Trends in the national averages of annual mean contaminant concentrations are reviewed. Statistical and other forms of analysis were used to determine the significance of the changes observed. Both the Wilcoxon statistical test and Paired T-test were used to assess the significance of changes occurring between consecutive years. The data were also analyzed using a Box Plot type of analysis, a convenient way to summarize and illustrate graphically the distribution of the stations with respect to the annual means calculated for the various contaminants. The data were further analyzed with respect to the percentage of stations meeting or exceeding the National Ambient Air Quality Objectives (NAAQO's). Included are some possible explanations for the relatively high concentrations at specific locations.

The averages of annual mean levels for Class I stations are compared with the concurrent values for all stations in order to determine how adequately these stations represent national air quality. Values of the recently defined Air Quality Index are reported for all Class I stations in operation during the 1977-79 period.

RÉSUMÉ

Le présent rapport traite des données sur la qualité de l'air présentées dans les extraits mensuels et annuels du Réseau national de surveillance de la pollution atmosphérique, entre 1970 et 1979, et décrit les tendances des moyennes des concentrations moyennes annuelles des divers polluants. Pour déterminer si ces variations étaient significatives, on les a soumises à des analyses statistiques et autres. Ainsi, on s'est servi du test de Wilcoxon et du test t de Student appliqués à des années consécutives, et d'une représentation graphique de la répartition des stations par rapport aux moyennes annuelles calculées. On a aussi calculé le pourcentage de stations où les objectifs nationaux de la qualité de l'air ambiant étaient ou n'étaient pas atteints. En outre des explications sont données sur certaines concentrations relativement élevées observées à certaines stations.

On a comparé les moyennes des concentrations annuelles moyennes observées aux stations de catégorie I avec les valeurs correspondantes observées dans toutes les stations pour déterminer si les premières donnaient un aperçu représentatif de la qualité de l'air au plan national. Pour toutes les stations de catégorie I, exploitées entre 1977 et 1979, on donne les valeurs de l'indice de la qualité de l'air, dont la notion vient d'être définie.

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SUMMARY

Average annual concentrations of most contaminants monitored in the National Air Pollution Surveillance (NAPS) network decreased substantially during the 1970-79 period. As would be expected, decreases were smaller in recent years, resulting in relatively constant levels during the 1977-79 period.

The average annual sulphur dioxide concentration decreased by approximately 40% from 1972 to 1979. Significant improvements relative to the National Ambient Air Quality Objectives also have occurred. In recent years, approximately 95% of the monitoring stations have satisfied the maximum acceptable annual level, compared with approximately 80% in 1974. Approximately 35% of the stations exceeded the maximum desirable annual level in 1979. For 24-hour periods, the percentage of stations exceeding the maximum desirable level increased from 40% in 1974 to 60% in 1979. However, the percentage of stations exceeding the maximum acceptable 24-hour level decreased to a comparable extent. The maximum tolerable level was exceeded only twice during the 1974-79 period. For 1-hour periods, approximately 45% of the stations exceeded the maximum desirable level while approximately 20% exceeded the maximum acceptable level. No significant short-term changes appear to have occurred.

Reliable nitrogen dioxide data are available for the 1977-79 period during which the average annual concentration decreased approximately 15%. The number of stations exceeding the maximum desirable annual level decreased from approximately 40% in 1977 to approximately 25% in 1979. No stations exceeded the maximum acceptable level in 1978 and 1979. In 1979, 8% of the stations exceeded the maximum acceptable 24-hour level, compared with 16% in 1977. No stations exceeded the maximum tolerable 24-hour level. Only 4% of the stations exceeded the maximum acceptable 1-hour level in 1979, representing a significant improvement over the previous two years. One site exceeded the maximum tolerable 1-hour level (one occasion only).

Carbon monoxide annual averages decreased approximately 40% between 1973 and 1976, but remained relatively constant thereafter. The small, but persistent decline in the percentages of stations exceeding the 8-hour objectives in earlier years was offset by small increases in 1979. Approximately 85%, 15% and 8% of the stations exceeded the maximum desirable, acceptable and tolerable 8-hour levels, respectively, in 1979. The percentages of stations exceeding the maximum desirable 1-hour level were slightly lower (60%) in 1978 and 1979 than in earlier years (70%).

Ozone measurements are reported for 1979 and the average of the annual mean concentrations was 1.5 parts per hundred million (pphm). Fifty-five percent of the stations exceeded the maximum acceptable annual level. All stations reported 24-hour average values in excess of the maximum acceptable level. Approximately 80% and 20% of the stations reported 1-hour values in excess of the maximum acceptable and tolerable levels, respectively.

The average of the annual geometric means for suspended particulates decreased by approximately 18% between 1970 and 1975, and since then has remained relatively constant at 60-70 micrograms per cubic metre ($\mu\text{g}/\text{m}^3$). In 1979, approximately 35% of the stations exceeded the maximum acceptable annual level, compared with 50% in 1974. Similarly, the percentage of stations exceeding the maximum desirable level decreased from 70% in 1974 to 50% in 1979. The percentage of stations meeting the 24-hour objective did not change significantly during the 1974-79 period: approximately 85% and 8% exceeded the maximum acceptable and tolerable levels, respectively.

The average of the annual geometric means for lead decreased approximately 45% from 1970 to 1979. The national average of the 24-hour maxima decreased from $3.0 \mu\text{g}/\text{m}^3$ in 1974 to $1.6 \mu\text{g}/\text{m}^3$ in 1979, further indicating a continuing improvement in ambient concentrations of this contaminant.

Although the average of the annual means for the soiling index decreased approximately 50% from 1970 to 1979, average levels were relatively constant during the 1975-79 period.

The averages of annual mean contaminant levels calculated for all stations and for Class I stations only have been compared. With the exception of lead, and to a lesser extent the soiling index, good agreement is shown for the 1977-79 period. Class I stations thus provide a representative national sample of contaminant levels and trends. Improved agreement for lead can be expected with the continuing decline in the use of leaded gasoline.

Annual air quality indexes for all Class I stations in operation during the 1977-79 period have been calculated. The majority of sites may be categorized as "Fair", 3 as "Good", and 5 as "Poor".

1 INTRODUCTION

1.1 Purpose

This is the third in a series of reports (1,2) on ambient air quality trends in Canada issued by the Air Pollution Control Directorate. The purpose is to summarize and interpret the ambient air quality data collected through the National Air Pollution Surveillance (NAPS) Network (3) and to report significant changes indicated by statistical and other forms of analysis. The monitoring results discussed cover the 1970-79 period.

The NAPS program was initiated in January 1970. The primary objectives of the network are to provide a nationwide data base for determining the extent of air pollution in Canada and to document trends occurring as a result of changing industrial activity, fuel use patterns and population density, more extensive use of pollution control equipment, and other factors. A network of air monitoring instruments is maintained in most Canadian cities with a population over 50 000. Monitoring instruments are usually located at sites where air pollution could present a problem and where a large number of people could be affected.

The site of air monitoring instruments is referred to as a "monitoring station", each of which is typified according to its immediate location within a city as:

C - Commercial

R - Residential

I - Industrial

Recently, guidelines have been established for categorizing NAPS stations as Class I, Class II, or Special (4). The Class I network is the permanent national network of comprehensive monitoring sites which will be operated over the coming decades; the sites involved are fundamentally population-oriented. The Class II stations may be operated on a shorter-term basis when and where there is a demonstrated need for monitoring. They are pollutant-oriented but not necessarily source-oriented. Special stations are established to monitor regional air quality, long-range transport or other specific pollution problems of national significance.

Any comparison of data between stations should consider these designations. Even when comparing contaminant levels in different cities for a specific type or class of station, caution should be exercised. The data represent the condition of the air in the vicinity of the individual monitoring stations but may not necessarily represent community-wide air quality.

The contaminants monitored are sulphur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O_3), suspended particulates (SP), and lead. In addition, the soiling or darkening potential of contaminants in the atmosphere is measured as the soiling index (COH), and measurements are made of dustfall and sulphation rates.

The great volume of air monitoring data generated by the nationwide network in recent years indicated the need for a single-value air quality index that could be used for socio-economic modelling, as an indicator of air quality trends, and as a basis for making rough comparisons of air quality in different urban areas. "Guidelines for an Annual Air Quality Index" was published by the Air Pollution Control Directorate, on behalf of the Federal-Provincial Committee on Air Pollution, in 1980 (5). The index is based on the National Ambient Air Quality Objectives (6) and assumes that at the defined objective levels, the effects of these individual air pollutants have equal importance with respect to the quality of the air. Of significance also is the fact that the objectives reflect the entire range of effects rather than just effects on health.

Since 1974, the NAPS annual summaries have not reported annual means of a contaminant for stations that do not meet a set of completeness criteria, because this could result in values of questionable accuracy. For SO_2 , NO_2 , O_3 , CO and COH, monthly or annual means are not calculated unless at least 50% of the hourly observations are available for the period concerned. Furthermore, the annual mean is not calculated unless monthly means are reported for at least two months in each quarter. For SP and lead, a monthly mean is not reported in the NAPS annual summaries unless a minimum of three samples is available for that month. The conditions for reporting the annual geometric mean are a minimum of 40 samples in the year with at least eight valid samples from each quarter.

1.2 Air Monitoring Program

When established in January 1970, the NAPS network had 43 monitoring instruments in 14 cities, measuring SO_2 , SP, lead and COH. The network expanded rapidly and by December 1979 the number of instruments had increased to 448 in 55 cities across the ten provinces and two territories. The list of contaminants monitored had expanded to include CO, NO_2 and O_3 *. The growth of the network is illustrated in Figure 1 while

* There were another 52 instruments used to measure dustfall and sulphation rate, but these two indicators of air pollution are not dealt with in this report.

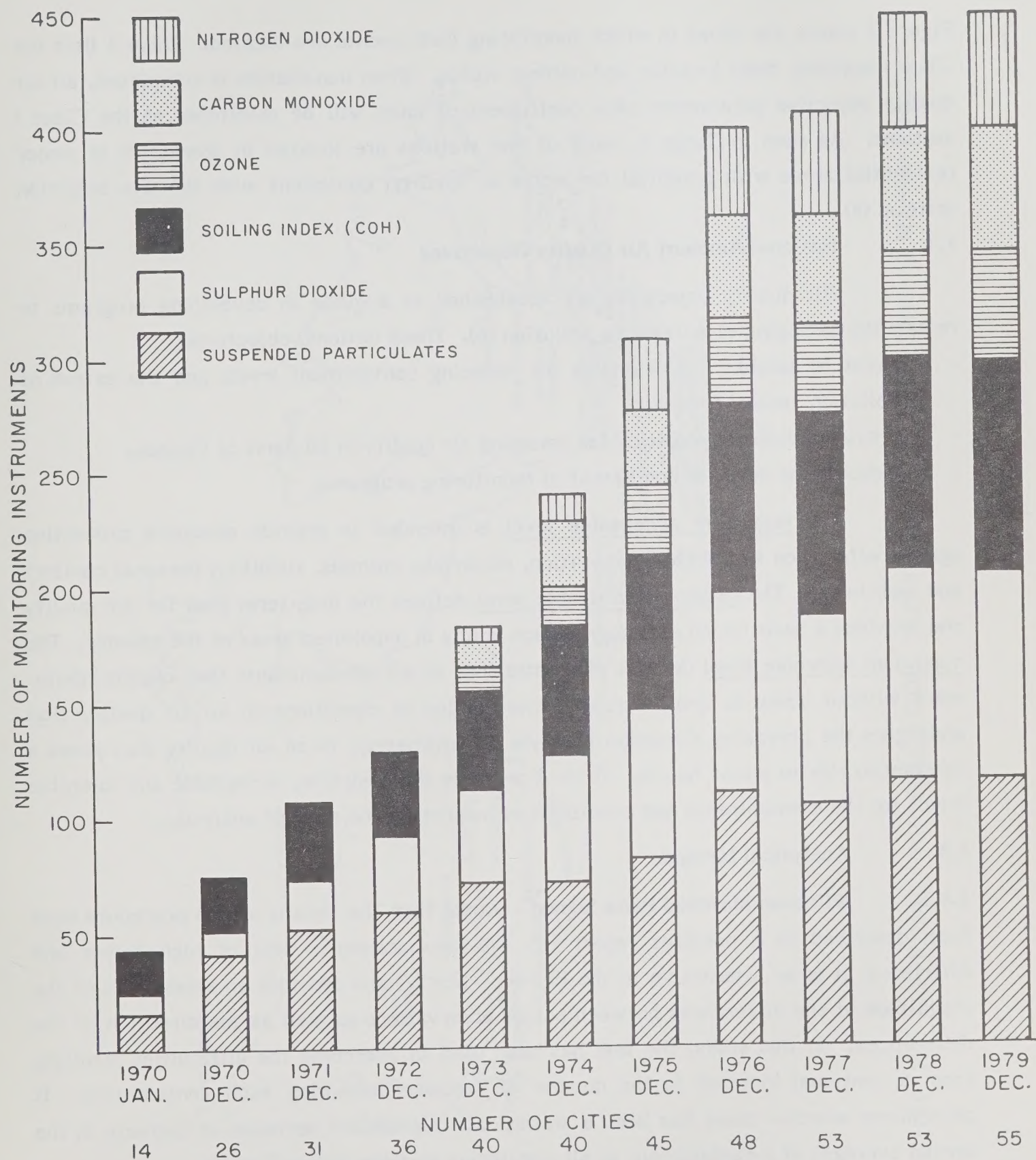


FIGURE 1 GROWTH OF NAPS NETWORK 1970 - 79

Figure 2 shows the cities in which monitoring instruments are located. Table 1 lists the Class I stations, their location and current status. When installation is completed, all air quality objective parameters plus coefficient of haze will be monitored at the Class I stations. As seen in Table 1, most of the stations are located in downtown or major residential areas with potential for worst air quality, consistent with the site selection criteria (4).

1.3 National Ambient Air Quality Objectives

Air quality objectives are established as a guide in developing programs to reduce the damaging effects of air pollution (6). These national objectives:

- assist in establishing priorities for reducing contaminant levels and the extent of pollution control needed;
- provide a uniform yardstick for assessing air quality in all parts of Canada;
- indicate the need for and extent of monitoring programs.

The maximum acceptable level is intended to provide adequate protection against effects on soil, water, vegetation, materials, animals, visibility, personal comfort and well-being. The maximum desirable level defines the long-term goal for air quality and provides a basis for an anti-degradation policy in unpolluted areas of the country. The maximum tolerable level denotes concentrations of air contaminants that require abatement without delay to avoid further deterioration of conditions to an air quality that endangers the prevailing Canadian lifestyle or, ultimately, to an air quality that poses a substantial risk to public health. Table 2 presents the desirable, acceptable and tolerable levels for the contaminants and conditions of interest in the present analysis.

1.4 Analytical Methods

1.4.1 Wilcoxon Matched Pairs Signed - Ranks Test The details of this procedure have been described in a previous report (1). A non-parametric test of high power and efficiency, it is an alternative to the Paired T-test (7) and provides an assessment of the magnitude of the differences between paired observations as well as the direction of the differences. In this study, the test has been used to overcome the difficulties resulting from a continual increase in the number of stations measuring each contaminant. It determines whether there has been a statistically significant decrease or increase in the annual averages of a contaminant at all monitoring stations across Canada.

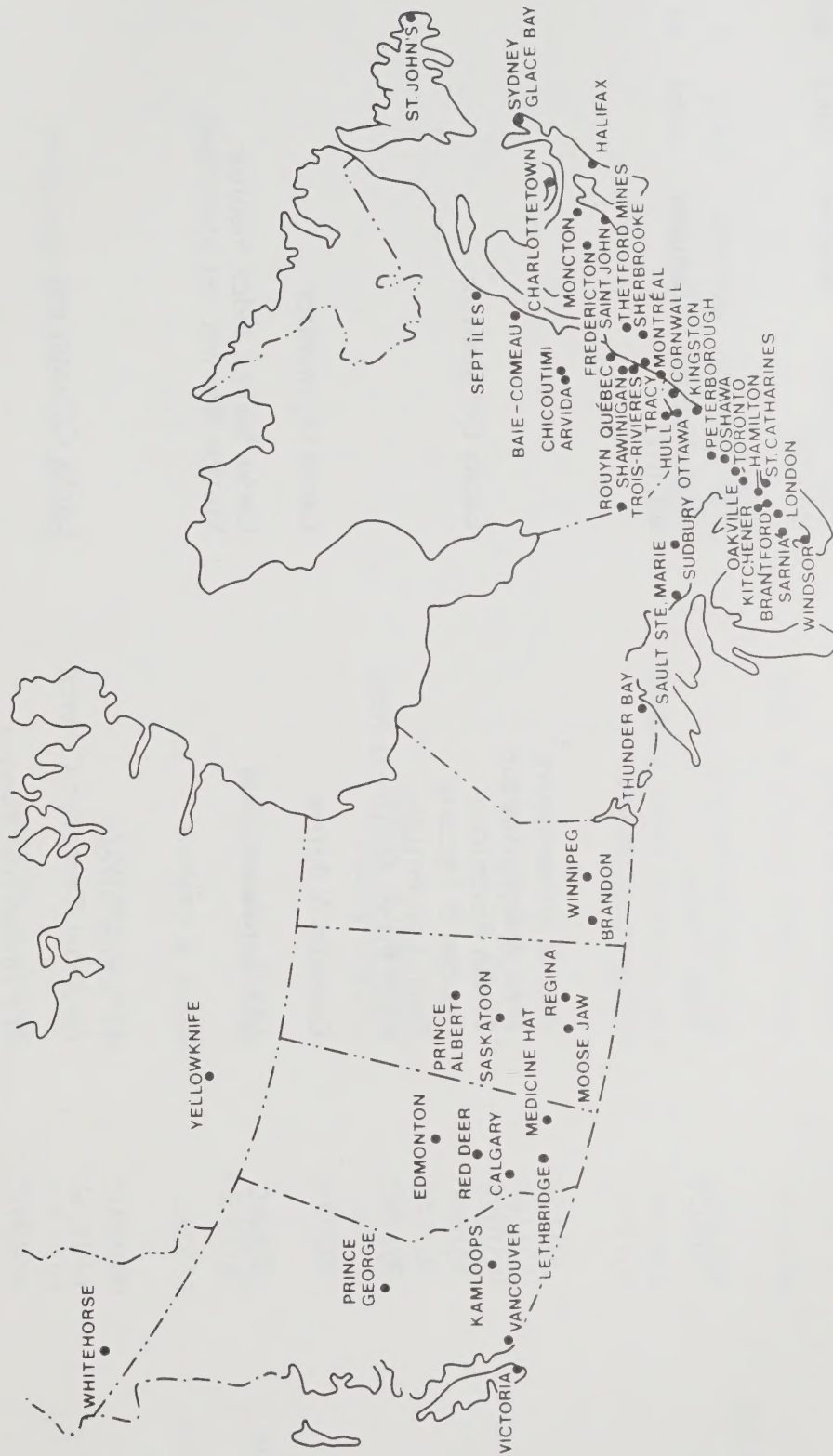


FIGURE 2 NATIONAL AIR POLLUTION SURVEILLANCE NETWORK (MARCH 1981)

TABLE 1 NATIONAL AIR POLLUTION SURVEILLANCE CLASS I STATIONS
(STATUS AS OF DECEMBER 31, 1980)

City	Station No.	Location	Comments
<u>Newfoundland</u>			
St. John's	10101C	Duckworth & Ordinance	Incomplete
<u>Nova Scotia</u>			
Halifax	30116C	Barrington & Duke	High-Volume 30101C Sampler sited at
<u>New Brunswick</u>			
Saint John	40202C	Post Office	High-Volume 40201C Sampler sited at
<u>Quebec</u>			
Montreal	50115C 50116R 50102R 50109C 50112C 50110C	Peel & Maisonneuve 3161 Joseph, Verdun Jardin Botanique Duncan & Decarie Boul. Laurentides Parc Pilon, Montreal-Nord	Lacks CO monitor
Hull	50203R	Gamelin & Joffre	Lacks O ₃ monitor
Quebec City	50304C 503XXX	155 Dorchester Sud	Lacks Soiling Index monitor Station site not yet identified
<u>Ontario</u>			
Ottawa	60101C 60105R	88 Slater Street National Research Council	Lacks CO monitor
Windsor	60204C	471 University Avenue	
Toronto	60401C 60412R 60410R 60415R 60402R 60413R	67 College Street Bathurst & Wilson Lawrence & Kennedy Queensway W. & Hurontario Don Mills, Science Centre Elmcrest Road	Lacks O ₃ monitor

TABLE I NATIONAL AIR POLLUTION SURVEILLANCE CLASS I STATIONS (continued)
(STATUS AS OF DECEMBER 31, 1980)

City	Station No.	Location	Comments
<u>Ontario</u>			
Hamilton	60501C 605XXX	Barton & Sanford	Station site not yet identified
London	60901C	King & Rectory	
St. Catharines	61301C	North & Geneva	
Kitchener	61501C	Edna & Frederick	
<u>Manitoba</u>			
Winnipeg	70119C 70118R	65 Ellen Street Jefferson & Scotia	
<u>Saskatchewan</u>			
Regina	80109C	1620 Albert Street	
<u>Alberta</u>			
Edmonton	90130C 90122R	10255-104th Street 127 Street & 133rd Avenue	
Calgary	90227C	1611-4th Street S.W.	High-Volume Sampler sited at 90204C
	90222R	39 Street & 29th Ave. N.W.	
<u>British Columbia</u>			
Vancouver	00112C	Robson & Hornby	High-Volume Sampler sited at 00109C
	00106R 00108I 00110R 00111I	2294 West 10th Avenue 250 West 70th Avenue E. Hastings & Kensington Rocky Pt. Park	
Victoria	00302C	1106 Cook Street	To be relocated

TABLE 2 NATIONAL AMBIENT AIR QUALITY OBJECTIVES^a

Pollutant	Averaging Time	Maximum Desirable Concentration		Maximum Acceptable Concentration		Maximum Tolerable Concentration	
Sulphur dioxide	Annual	1.1	pphm*	2.3	pphm	-	-
	24-H	6	pphm	11	pphm	31	pphm
	1-H	17	pphm	34	pphm	-	-
Suspended Particulates	Annual	60	$\mu\text{g}/\text{m}^3$ **	70	$\mu\text{g}/\text{m}^3$	-	-
	24-H	-	-	120	$\mu\text{g}/\text{m}^3$	400	$\mu\text{g}/\text{m}^3$
Ozone	Annual	-	-	1.5	pphm	-	-
	24-H	2	pphm	3	pphm	-	-
	1-H	5	pphm	8	pphm	15	pphm
Carbon Monoxide	8-H	5	ppm***	13	ppm	17	ppm
	1-H	13	ppm	31	ppm	-	-
Nitrogen Dioxide	Annual	3.2	pphm	5.3	pphm	-	-
	24-H	-	-	11	pphm	16	pphm
	1-H	-	-	21	pphm	53	pphm

* Parts per hundred million

** Micrograms per cubic metre

*** Parts per million

a Conditions of 25°C (77°F) and 101.32 kPa (760 mm Hg) are used as the basis for conversion from $\mu\text{g}/\text{m}^3$ to ppm or pphm.

The annual mean levels of a contaminant for two consecutive years are compared at each station. Data for two consecutive years are required and the size of the increase or decrease is noted. If a high proportion of stations experienced an increase, the test will show whether the increase was statistically significant for those two years. A 95% confidence interval is used. The results of the tests from 1970 to 1979 are given for each contaminant in Table 3, and will be discussed further in the sections on individual contaminants.

The Wilcoxon test was also used to determine the equivalence of trends in air quality defined by Class I stations as compared to all stations, using 1978-79 data. As shown in Table 4, the two groups of stations show similar trends for sulphur dioxide, carbon monoxide, soiling index, suspended particulates and lead, but not for nitrogen dioxide. Comparisons of the longer-term trends indicated by Class I stations and all stations are given in the sections on individual contaminants.

TABLE 3 STATISTICALLY SIGNIFICANT CHANGES IN AIR POLLUTION LEVELS, BASED ON ANNUAL MEANS FOR NAPS STATIONS ACROSS CANADA DURING 1970-79.

Contaminant	1970-71	71-72	72-73	73-74	74-75	75-76	76-77	77-78	78-79
Sulphur Dioxide	↗	→	↘	→	↘	→	→	↘	→
Nitrogen Dioxide	N/A	N/A	N/A	N/A	N/A	N/A	N/A	→	↘
Carbon Monoxide	N/A	N/A	N/A	↘	↘	→	→	→	→
Ozone	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	-
Suspended Particulates	↘	↘	↗	→	↘	→	↘	→	↗
Lead	↘	→	→	↘	↘	↘	↘	↘	↘
Soiling Index	→	→	→	→	→	→	→	→	→

↗ = Statistically Significant Increase
 ↘ = Statistically Significant Decrease
 → = Statistically No Significant Change
 N/A = Not Applicable, Pollutant not Monitored or Results not Considered Reliable.

The Class I station data for 1978-79 were also used to compare the Paired T-test and Wilcoxon Matched Pairs Test. The Paired T-test uses the t distribution to test the null hypothesis for the difference within matched pairs of data. The Wilcoxon test is similar in that it also uses the variability of the difference between two matched sets of data to determine if a statistically significant difference exists. A 95% confidence limit normally is used. The trend analyses for the 1978-79 data for each contaminant by the two methods are summarized in Table 4. In four out of six cases, the indicated trends are in agreement, representing a reasonable degree of consistency between the two methods. For NO_2 and soiling index, the Wilcoxon test indicates no trend, whereas the Paired T-test indicates a significant decrease and increase, respectively.

It is emphasized that these statistical methods take into account changes in air contaminant levels which may be due to monitoring instrument inaccuracies and other errors, when determining whether the change is significant. A disadvantage of these tests when applied to data for consecutive years is that slight increases or decreases in each

TABLE 4 COMPARISON OF TREND ANALYSES USING WILCOXON AND PAIRED T-TESTS (1978-79 DATA)

Pollutant	Wilcoxon Test All Stations	Wilcoxon Test Class I Stations	Paired T-Test Class I Stations
SO ₂	No Trend	No Trend	No Trend
CO	No Trend	No Trend	No Trend
NO ₂	Signif. Decrease	No Trend	Signif. Decrease
Soiling Index	No Trend	No Trend	Signif. Increase
Suspended Particulates	Signif. Increase	Signif. Increase	Signif. Increase
Lead	Signif. Decrease	Signif. Decrease	Signif. Decrease

year, not considered statistically significant in consecutive years, might lead to substantial increases or decreases over the longer term. Thus, other methods must be used to assess the significance of longer-term trends, and to this end longer-term trend plots are included in this report.

1.4.2 Box Plot Analysis. The Box Plot is basically a graphical technique used to show the distribution of the stations with respect to the annual means calculated for the various contaminants. The plotting convention for the Box Plot is shown in Figure 3.

For a given contaminant, the annual averages (or geometric means in the case of SP and lead) of all stations are grouped and ranked*. The percentiles indicate the percentage of stations with annual averages less than (cleaner) or greater than (dirtier) the specific levels identified.

In addition to the percentiles (10, 25, 50, 75 and 90), the annual average of all stations for the particular contaminant in a given year is also displayed. Thus, the annual trends at the cleaner (10-25 percentiles), average (mean, median (50)), and dirtier (75 and 90 percentiles) stations can be analyzed separately (see Appendix 1, Summary Data-Urban Air Quality Trends, 1970-79).

* The change in the number of stations from year to year could possibly bias the annual average or percentiles calculated, thereby distorting actual trends. To account for this, averages and percentiles were calculated for both all stations and Class I stations. Values and corresponding trends for both were found to be similar. Consequently, because the total NAPS network gives a more representative national sample, all stations have continued to be used in the analysis.

1.4.3 Analysis - With Respect to NAAQO's. A third type of analysis used is based on the percentages of stations meeting or exceeding the NAAQO's in given years. This type of analysis is crude as it is insensitive to movement within particular ranges. For example, all stations recording an annual mean for a particular contaminant may experience a drop in level from one year to the next. However, if none of the annual means drops below a particular objective, then this type of analysis would indicate no change. Consequently, it is used more in a supportive role, to substantiate the first two types of analysis. For the same reason as in the Box Plot analysis, all stations have been used in calculating the percentage of stations meeting or exceeding NAAQO's.

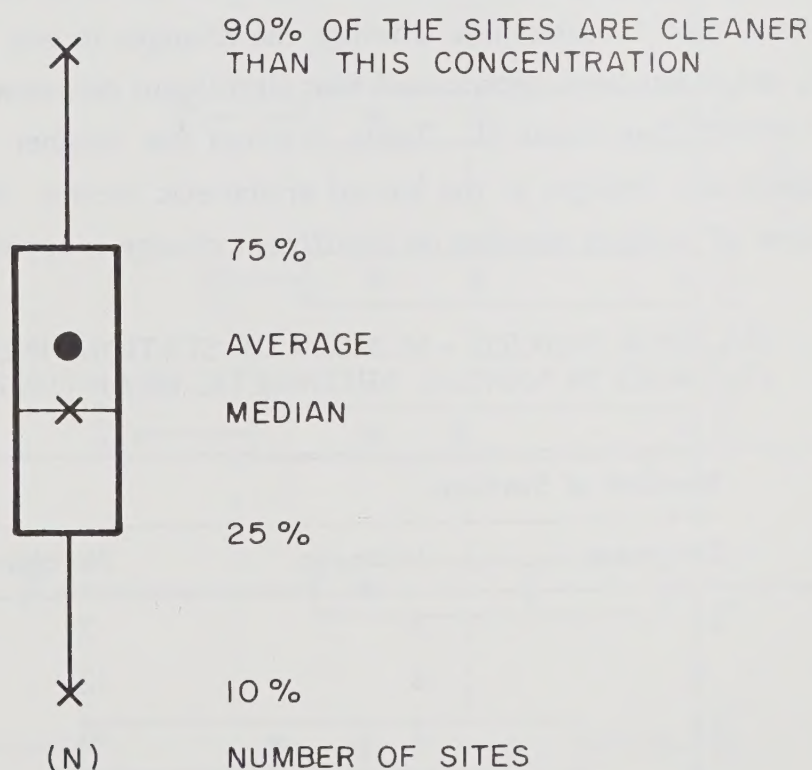


FIGURE 3 CONCENTRATION BOX PLOTTING LEVELS

2 SULPHUR DIOXIDE

Sulphur dioxide (SO_2) is a colourless gas and normally is not present in urban air at concentrations high enough for its odour to be detected. It is emitted into the atmosphere mainly from the primary production of copper and nickel, the combustion of sulphur-containing fuels, natural gas processing, iron ore processing and petroleum refining. Although air quality objectives for this contaminant have been set on the basis of known primary effects on health, vegetation and materials, secondary effects resulting from the formation of acid rain are now also of concern.

2.1 Annual Arithmetic Means

The average of SO_2 annual means recorded by the NAPS network has decreased from 2.1 pphm in 1972 to 1.2 pphm in 1979 (see Figure 4 and Appendix I). Only relatively small changes in annual mean values have occurred in recent years. Statistical methods have been used to determine whether the changes in any two consecutive years are significant, and it has been determined that significant decreases occurred in 1972-73, 1974-75, and 1977-78 (See Table 3). Table 5 shows the number of stations indicating statistically significant changes in the annual arithmetic means. A trend in recent years to a larger number of stations showing no significant change is apparent.

TABLE 5 SULPHUR DIOXIDE - NUMBER OF STATIONS INDICATING CHANGES IN ANNUAL ARITHMETIC MEAN (1972-79)

Period	Number of Stations			Total
	Decrease	Increase	No change * *	
1972-73*	23	2	7	32
1973-74	6	6	12	24
1974-75*	11	2	10	23
1975-76	7	4	18	29
1976-77	11	9	20	40
1977-78*	19	4	30	53
1978-79	12	6	40	58

* Statistically, there was a significant decrease in sulphur dioxide levels for the years 1972-73, 1974-75, and 1977-78.

** Includes differences of less than 0.1 pphm to ensure changes are not due to monitoring instrument inaccuracies or other errors.

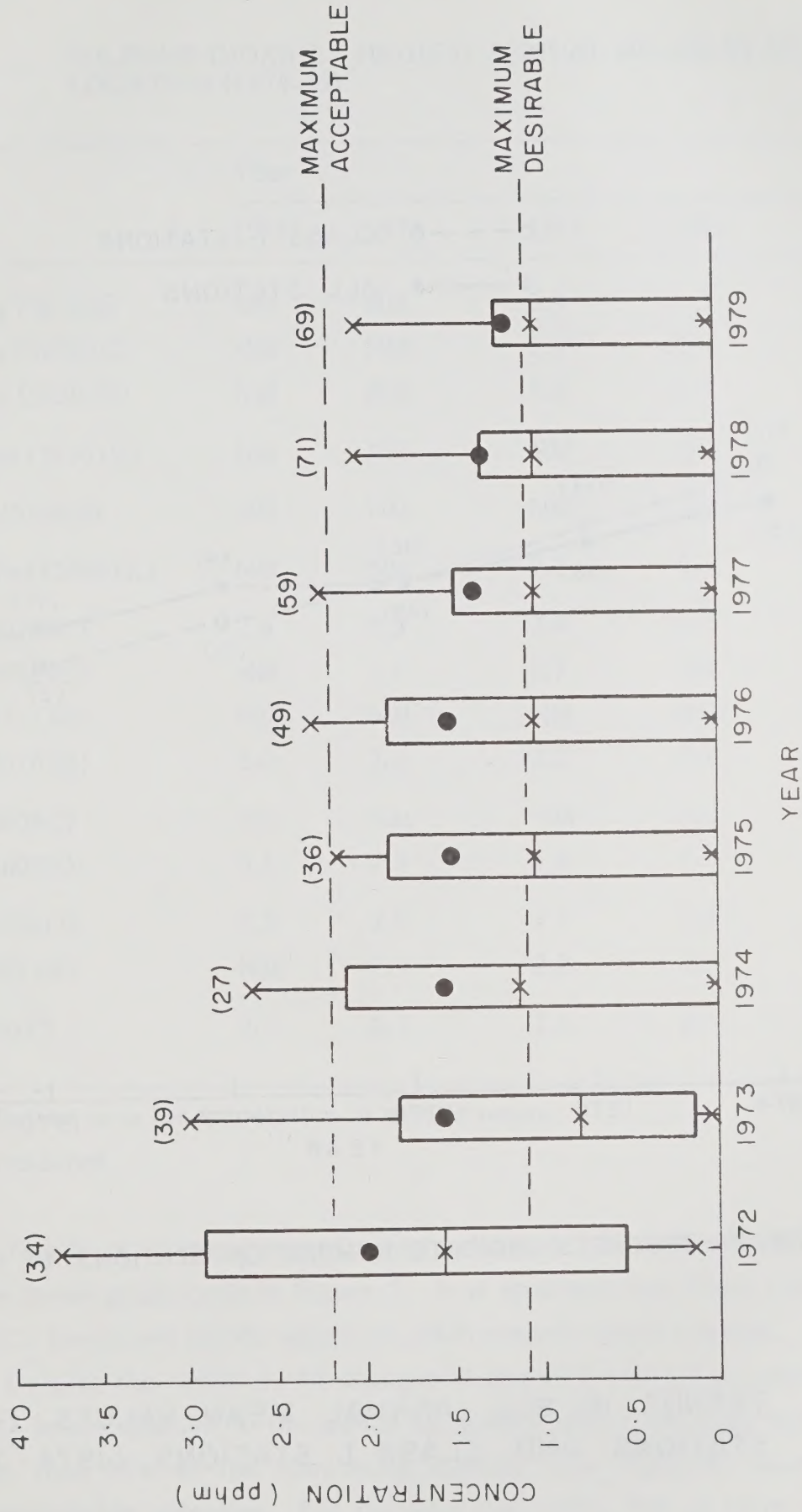
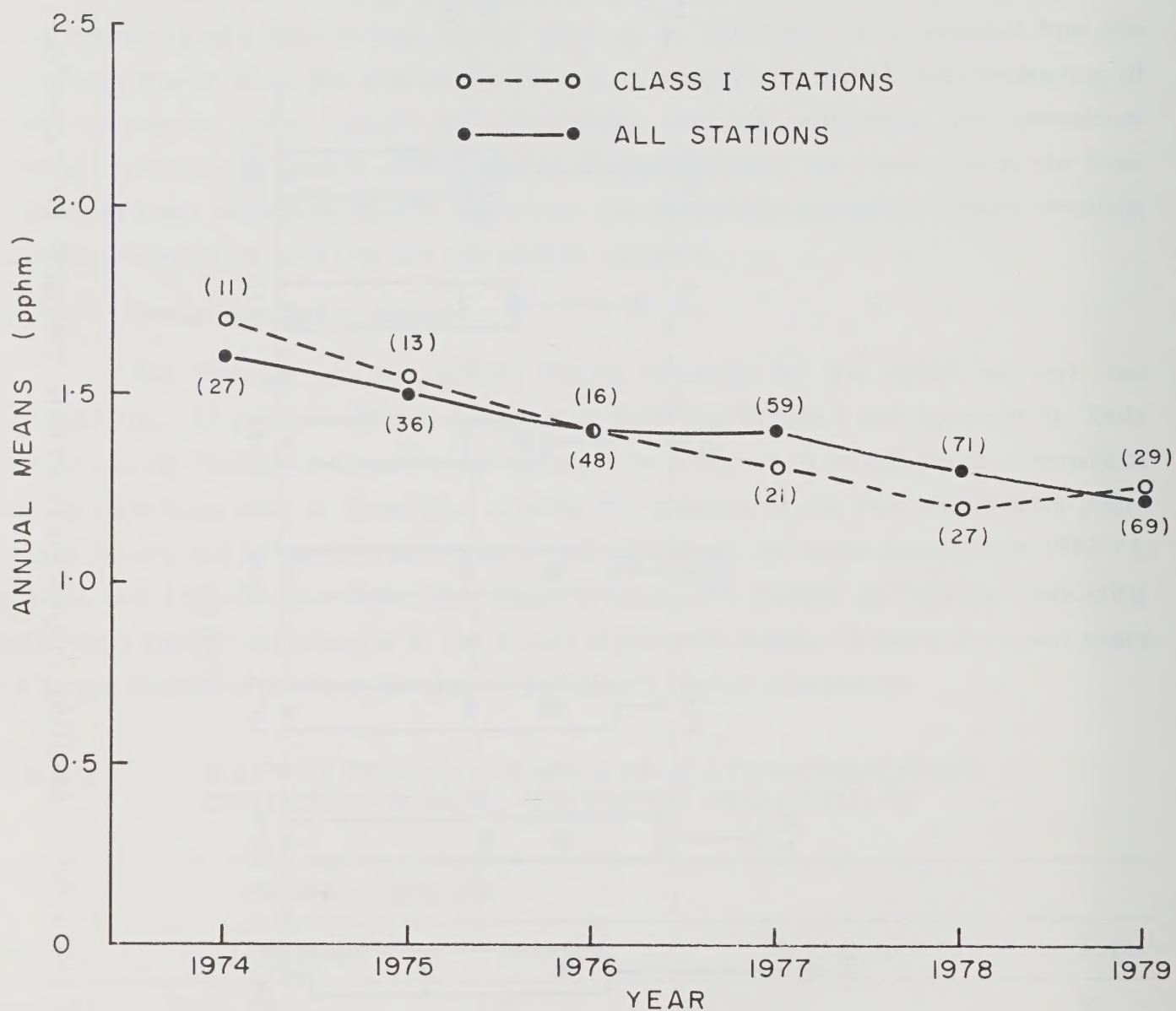


FIGURE 4 SULPHUR DIOXIDE - ANNUAL CONCENTRATION TRENDS IN CANADA (1972 - 79)



NUMBERS IN BRACKETS INDICATE NUMBER OF STATIONS IN OPERATION

FIGURE 5 TRENDS IN SO_2 ANNUAL MEAN VALUES FOR ALL STATIONS AND CLASS I STATIONS (1974-79)

TABLE 6 SULPHUR DIOXIDE - HIGHEST ANNUAL MEANS BY STATION
LOCATION (1974-79)

City	Year					
	1974	1975	1976	1977	1978	1979
Quebec City (50303I)	NM	NM	3.0	4.3	2.0	2.5
Quebec City (50304C)	NM	NM	2.4	2.6	1.5	1.8
Quebec City (50305R)	NM	NM	4.6	2.0	1.1	---
Baie Comeau (51301R)	NM	NM	NM	NM	3.6	2.0
Shawinigan (51201I)	NM	NM	NM	NM	2.6	---
Trois-Rivieres (50801R)	NM	NM	2.2	2.3	2.2	1.6
Montreal (50104C)	2.6	2.5	2.4	1.9	1.8	1.7
Montreal (50105C)	NM	3.7	2.7	3.6	2.8	2.5
Montreal (50115C)	NM	NM	NM	NM	2.7	2.7
Montreal (50103R)	3.0	2.2	2.2	2.1	2.8	1.9
Sudbury (60606C)	NM	NM	NM	2.3	1.3	1.1
Sudbury (60602R)	3.3	2.8	1.9	1.5	1.2	1.2
Windsor (60204C)	3.3	2.9	2.7	2.2	1.8	1.3
Windsor (60211R)	NM	2.3	2.0	1.5	1.5	1.8
Sarnia (61001C)	2.7	2.3	2.4	2.3	1.9	NM

--- Insufficient data for calculation of a valid mean.

NM Not measured.

Trends in average annual mean values for all stations and for only Class I stations are shown graphically in Figure 5. It is apparent that Class I stations provide a sample of SO₂ levels and trends typical of urban centres across Canada.

Despite the rather small changes in annual mean values, significant improvement in SO₂ levels relative to the annual air quality objectives have occurred. In recent years, more than 90% of the monitoring stations have reported values less than the maximum acceptable objective. For the past five years, 50% or more of the sites have

met or surpassed the maximum desirable objective. Table 7A summarizes the percentages of stations in various ranges with respect to the annual NAAQO's for the 1974-79 period. Figure 6A shows the percentages of stations exceeding the objectives. The improvement achieved during this period is apparent in both instances.

Despite the fact that overall mean values from all Canadian stations meeting NAPS siting criteria now compare favourably with the objectives, some stations continue to show values exceeding the maximum acceptable level of 2.3 pphm (Table 6). Stations in both Quebec City and Montreal continued to show high levels in 1979. The high levels recorded at the Quebec City industrial station at Centre Loisirs Limoilou (503031) can be attributed to emissions from a local pulp and paper processing plant. The continuing use of oil as a major residential heating fuel, as well as for commercial and institutional purposes in Quebec also results in a significant contribution to SO₂ levels in urban areas.

2.2 Short-Range Concentrations

24-Hour Maximum Levels

The percentages of stations in the ranges defined by the 24-hour NAAQO's indicate that there was a change in the frequency distribution of 24-hour average SO₂ values between 1974 and 1979 (Table 7 and Figure 6). Over the period, the percentage of stations exceeding the maximum desirable level increased from 40% to 59%. However, the number of stations exceeding the maximum tolerable 24-hour level did not change significantly, and thus a small change in the frequency distribution of 24-hour average values appears to have occurred in favour of a larger number of values in the 6.1-11 pphm range. The number of monitoring stations considered increased from 55 in 1974 to 90 in 1979 and the resulting changes in the average characteristics of the station population could account for this change.

The maximum tolerable level was exceeded only twice during the 1974-79 period: once at the Quebec City industrial station of Centre Loisirs Limoilou in 1977 and once at the residential station in Baie Comeau in 1978. In 1979, both of these stations exceeded the maximum acceptable level of 11 pphm. Predominant sources in the vicinity of the Centre Loisirs Limoilou site were discussed above. Contributing to the SO₂ levels measured at the Baie Comeau station were several industrial sources, including an aluminum smelter, a pulp and paper mill, as well as residential, commercial and institutional heating.

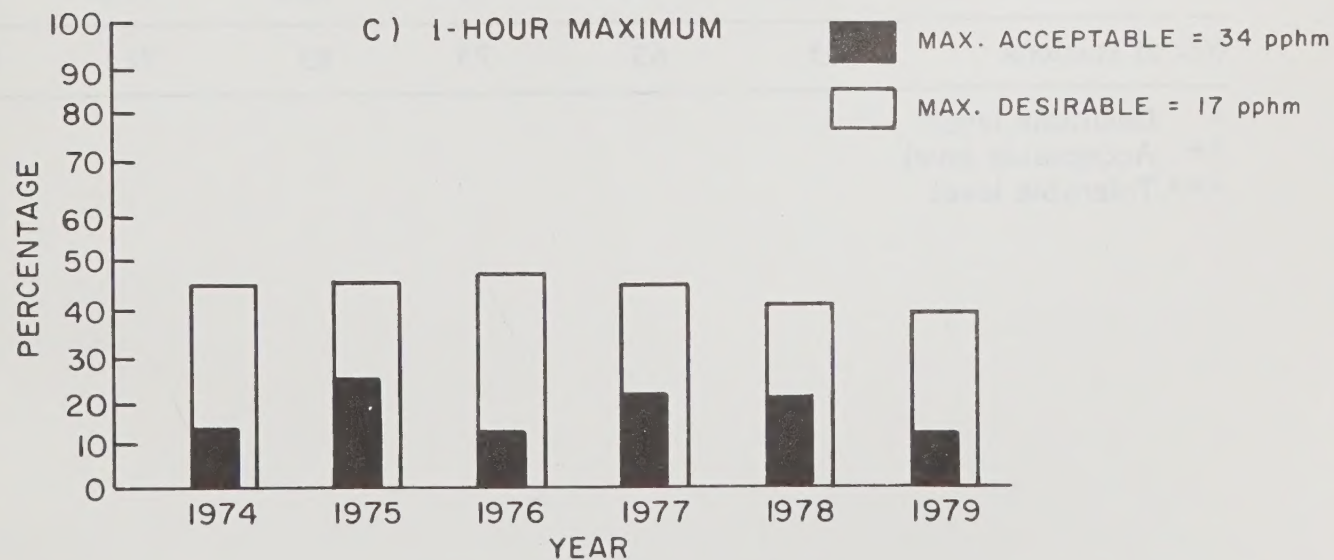
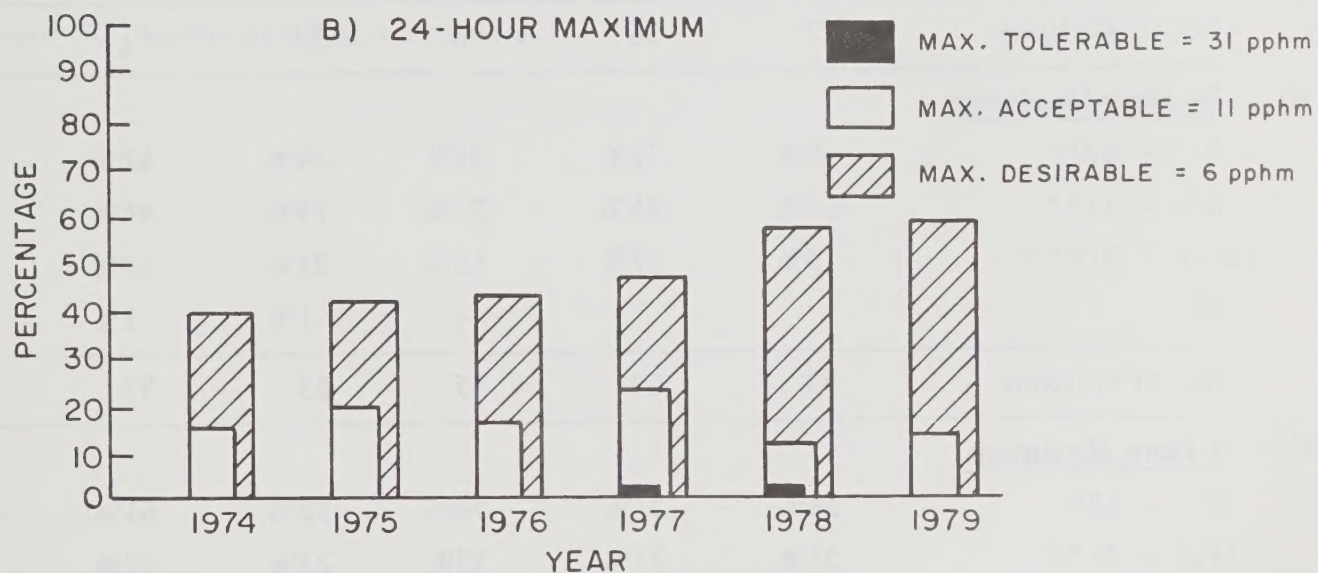
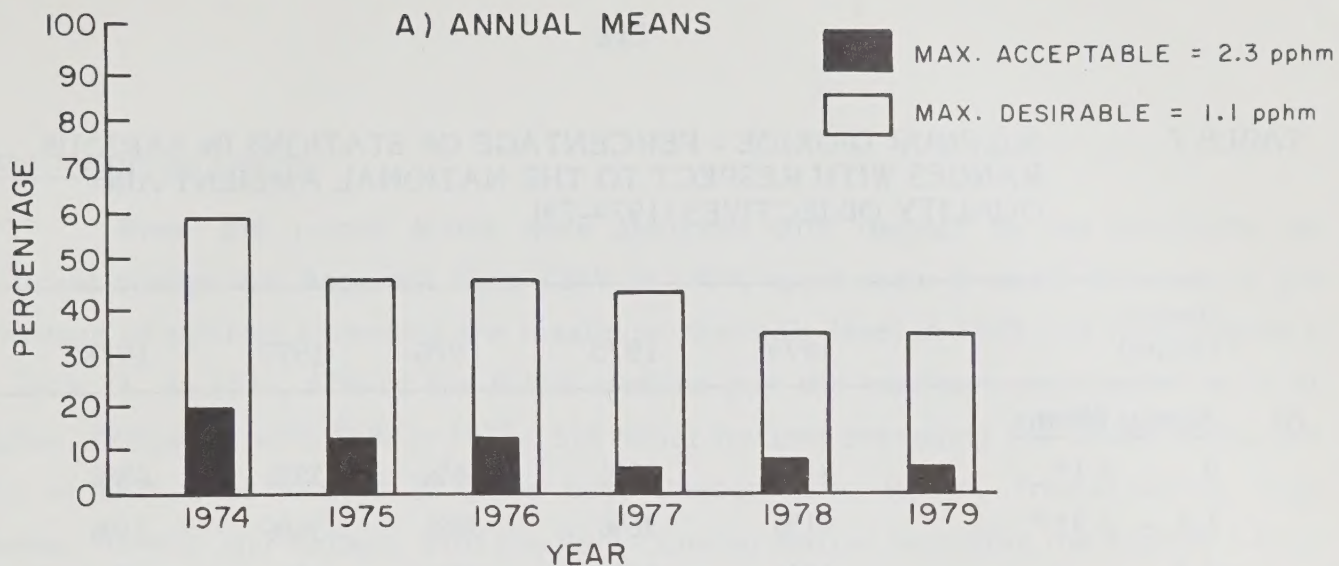


FIGURE 6 SULPHUR DIOXIDE - PERCENTAGE OF STATIONS EXCEEDING NAAQO'S (1974-79)

TABLE 7 SULPHUR DIOXIDE - PERCENTAGE OF STATIONS IN VARIOUS RANGES WITH RESPECT TO THE NATIONAL AMBIENT AIR QUALITY OBJECTIVES (1974-79)

Range (pphm)	1974	1975	1976	1977	1978	1979
A) Annual Means						
0 - 1.1*	41%	53%	54%	59%	68%	67%
1.2 - 2.3**	41%	36%	36%	36%	25%	29%
>2.3	18%	11%	10%	5%	7%	4%
No. of stations	27	36	48	59	71	69
B) 24-Hour Maximum						
0 - 6.0*	60%	59%	56%	54%	42%	41%
6.1 - 11**	25%	24%	29%	24%	44%	44%
11.1 - 31***	15%	17%	15%	21%	13%	15%
>31			--	1%	1%	--
No. of stations	55	63	75	83	92	90
C) 1-Hour Maximum						
0 - 17*	56%	57%	56%	59%	61%	62%
17.1 - 34**	31%	21%	33%	23%	22%	27%
>34	13%	22%	11%	18%	17%	11%
No. of stations	55	63	75	83	92	89

* Desirable level

** Acceptable level

*** Tolerable level

1-Hour Maximum Levels

When the 1-hour levels were analyzed with respect to the NAAQO's, no significant change was apparent from 1974 to 1979, apart from a small decrease in the percentage of stations exceeding the maximum desirable level in 1978 and 1979 (Figure 6 and Table 7). In 1974, 87% of the NAPS stations met the maximum acceptable level of 34 ppm, compared with 89% in 1979. Individual stations exceeding the 1-hour maximum levels in 1979 were located in Glace Bay, Quebec City, Rouyn, Trois-Rivières, Baie Comeau, Toronto and Sudbury with the Baie Comeau station recording the highest 1-hour concentration in 1979. Specific industrial point sources contribute significantly to ambient SO_2 levels at all of these sites.

3 NITROGEN DIOXIDE

Gasoline-powered motor vehicles are the predominant source of nitrogen dioxide. Other significant sources include diesel engines, industrial fuel combustion, power plants, forest fires and railway engines. Although the NAAQO's for this contaminant were established to prevent adverse human health effects and plant damage, the major role of nitrogen oxides in atmospheric photochemical reactions is also recognized, as is their significant contribution to the acid rain phenomenon.

As shown in Figure 1, nitrogen dioxide monitors were first installed in the NAPS network in 1973. Data for the 1974-77 period were discussed in a previous report (2). It has since been concluded that the data obtained prior to 1977 are unreliable as a result of instrumental and calibration difficulties. NO₂ data for the 1977-79 period only are considered in this report.

3.1 Annual Arithmetic Means

From 1977 to 1979, the average of NO₂ annual means decreased from 3.1 ppm to 2.5 ppm (See Appendix I and Figure 7). Statistical tests indicate that a significant decrease in the average value occurred for the 1978-79 period (Table 3); the number of stations indicating changes in the annual arithmetic means are listed in Table 8. The averages of annual mean values for all stations and for Class I stations are plotted in Figure 8 for the 1977-79 period and the two sets of stations show similar trends and levels.

TABLE 8 NITROGEN DIOXIDE - NUMBER OF STATIONS INDICATING CHANGES IN ANNUAL ARITHMETIC MEAN (1977-79)

Period	Number of Stations			Total
	Decrease	Increase	No change * *	
1977-78	8	9	4	21
1978-79*	12	4	7	23

* Statistically, the decrease in levels was significant.

** Includes stations indicating differences of less than 0.1 ppm to ensure changes are not due to monitoring instrument inaccuracies or other errors.

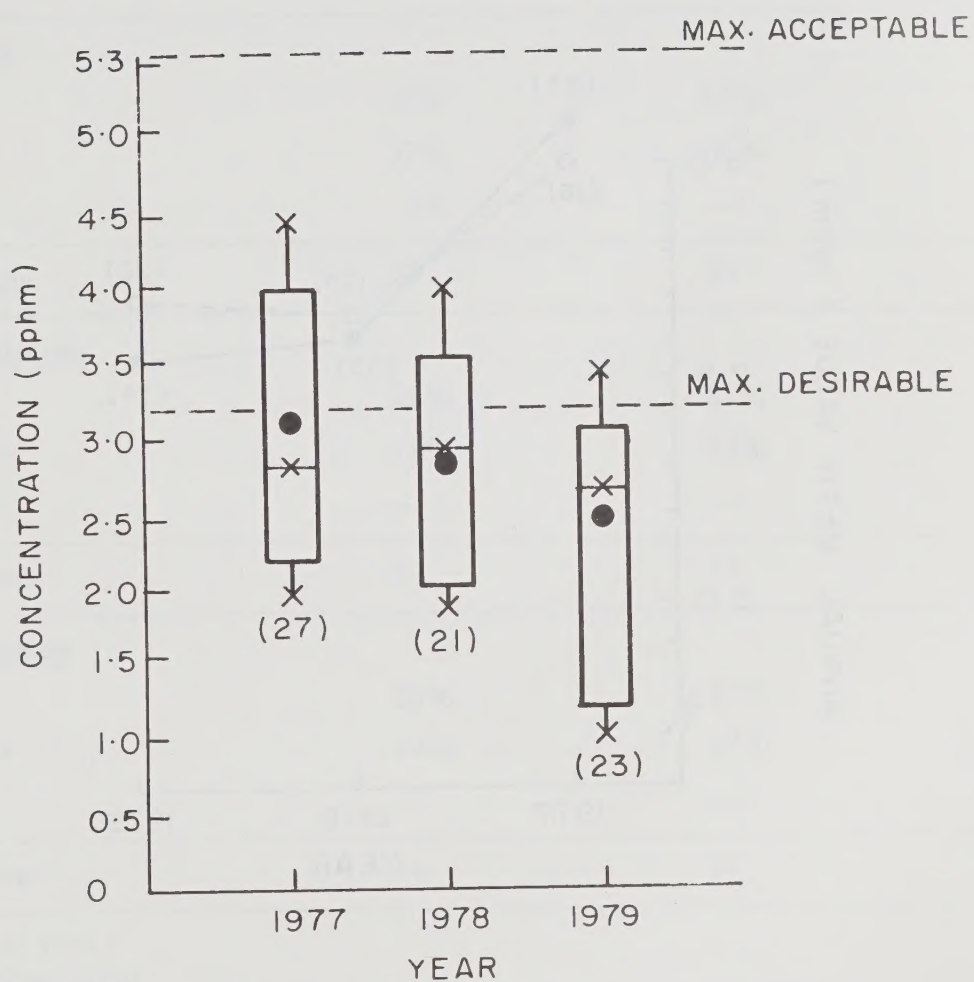
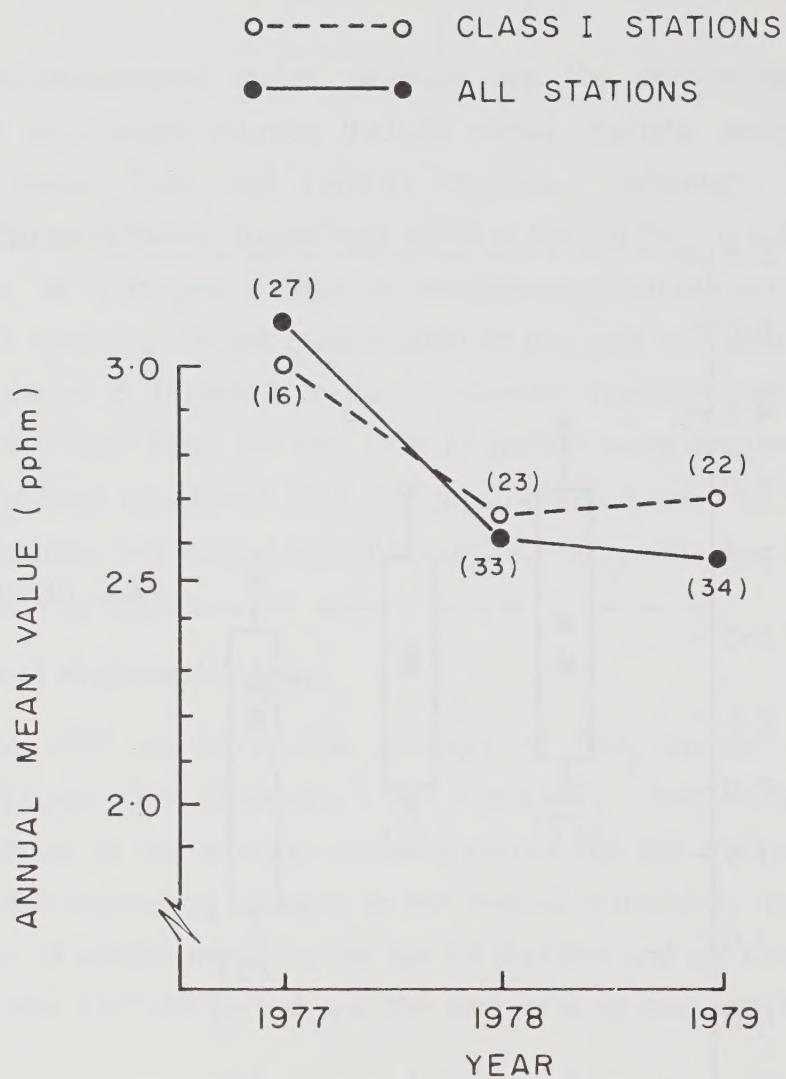


FIGURE 7 NITROGEN DIOXIDE - ANNUAL CONCENTRATION TRENDS IN CANADA (1977 - 79)



NUMBERS IN BRACKETS INDICATE NUMBER
OF STATIONS IN OPERATION.

FIGURE 8 TRENDS IN NO₂ ANNUAL MEAN VALUES FOR ALL
STATIONS AND CLASS I STATIONS (1977- 79)

TABLE 9 NITROGEN DIOXIDE - PERCENTAGE OF STATIONS IN VARIOUS RANGES WITH RESPECT TO NATIONAL AMBIENT AIR QUALITY OBJECTIVES (1977-79)

Range (pphm)	1977	1978	1979
A) <u>Annual Means</u>			
0 - 3.2*	59%	64%	76%
3.3 - 5.3**	37%	36%	24%
>5.3	4%	---	---
No. of stations	27	33	34
B) <u>24-Hour Maximum</u>			
0 - 11**	84%	87%	92%
11.1 - 16***	16%	13%	8%
>16	---	---	---
No. of stations	44	47	49
C) <u>1-Hour Maximum</u>			
0 - 21**	86%	87%	96%
21.1 - 53***	14%	13%	2%
>53	---	---	2%
No. of stations	44	47	49

* Desirable level

** Acceptable level

*** Tolerable level

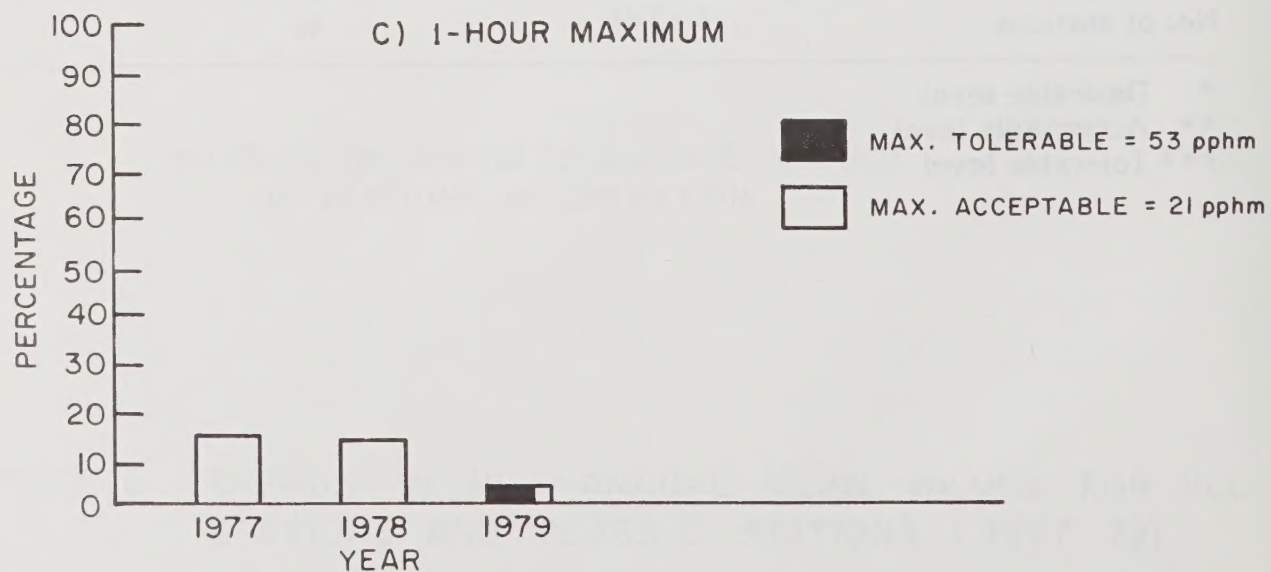
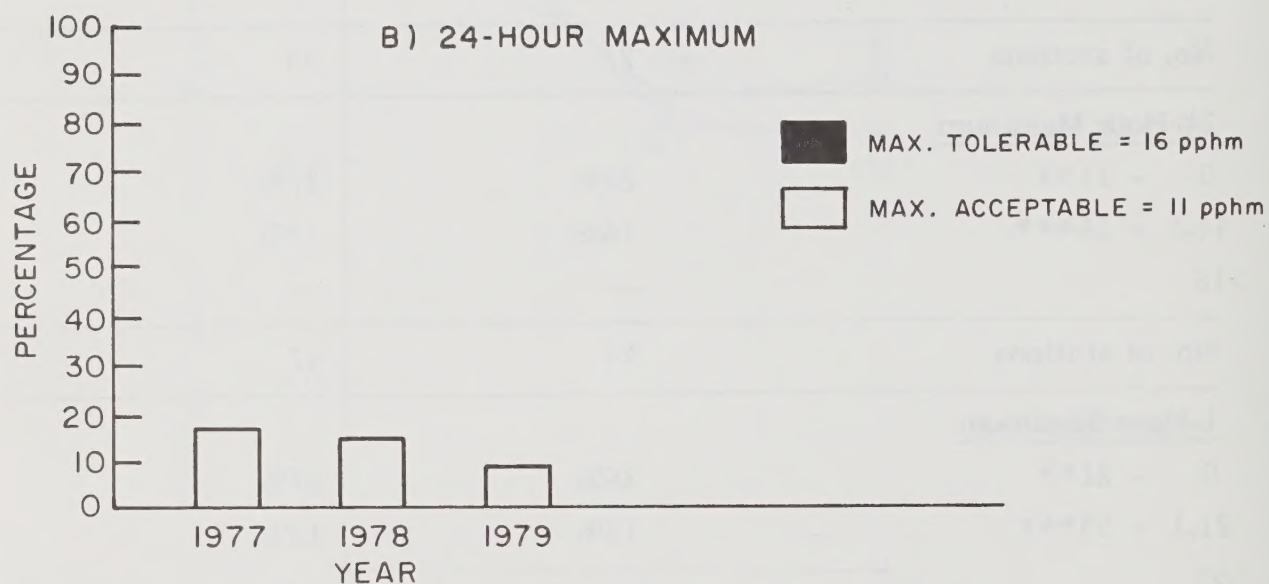
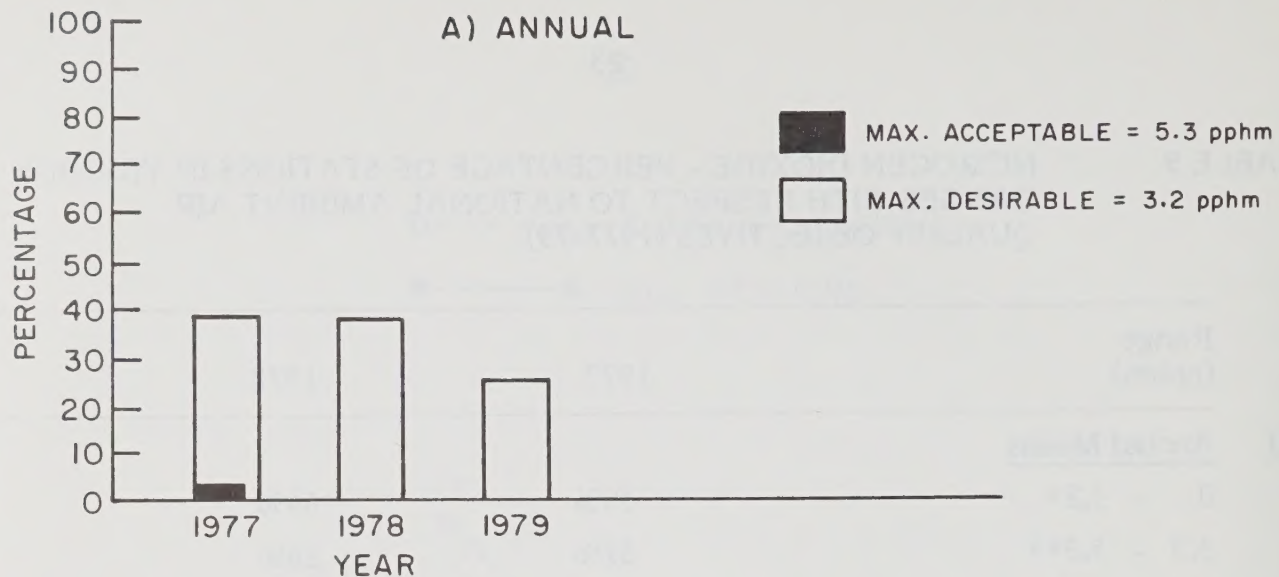


FIGURE 9 NITROGEN DIOXIDE-PERCENTAGE OF STATIONS
EXCEEDING NAAQS'S (1977-79)

The average of NO₂ annual means never exceeded the maximum desirable level from 1977 to 1979. Furthermore, the percentage of stations meeting or exceeding the annual air quality objectives each year shows that some improvement in air quality with respect to NO₂ was achieved. As shown in Table 9A and Figure 9A, the number of stations meeting the maximum desirable level increased from 59% in 1977 to 76% in 1979. No individual stations exceeded the acceptable level during 1978 and 1979. The highest NO₂ annual mean in 1979 occurred at a commercial (city centre) site in Edmonton (4.2 pphm).

3.2 Short-Range Concentrations

24-Hour Maximum Levels

Improvements noted in annual mean NO₂ values were paralleled by a trend to lower percentages of stations exceeding the 24-hour maximum acceptable level of 11 pphm (Figure 9B and Table 9B). In 1977, 84% of the stations met the maximum acceptable 24-hour level of 11 pphm, compared with 92% in 1979. All stations met the maximum tolerable 24-hour level of 16 pphm during the 1977-79 period. The individual stations exceeding the maximum acceptable 24-hour level during 1979 were located in Toronto, Edmonton and Calgary.

1-Hour Maximum Levels

The percentage of stations meeting the maximum acceptable 1-hour level of 21 pphm was significantly higher in 1979 than in the previous two years, with this level being exceeded at only 4% of the sites (Table 9C and Figure 9C). However, one of the sites (in Calgary) exceeded the maximum tolerable 1-hour level in 1979, while none did so in 1977 and 1978. The maximum tolerable level was exceeded only once, with a maximum value of 100 pphm reported.

4 CARBON MONOXIDE

Carbon monoxide is produced by the incomplete combustion of any organic fuel. The primary source of CO emissions is the gasoline-powered vehicle. Other important sources are forest fires, the non-highway use of gasoline, and the petroleum refining process. Ambient air quality objectives for this pollutant are concerned with the prevention of chronic health effects in humans.

4.1 Annual Arithmetic Means

The average of CO annual means for the NAPS network decreased from 2.7 ppm in 1973 to 1.7 ppm in 1976, but remained relatively constant during the 1976-79 period (Figure 10). It can be seen that increases at the poorer stations in 1978 and 1979 mitigated the downward trend of earlier years.

When statistical analysis was applied to determine whether the change between any two consecutive years was significant, CO levels were found to have decreased significantly only in 1973-74 and 1974-75 (Table 3). No trend is indicated for subsequent years. The number of stations indicating changes in annual arithmetic means for CO are summarized in Table 10.

TABLE 10 CARBON MONOXIDE - NUMBER OF STATIONS INDICATING CHANGES IN ANNUAL ARITHMETIC MEAN (1973-79)

Period	Number of Stations			Total
	Decrease	Increase	No change * *	
1973-74*	7	1	1	9
1974-75*	9	3	3	15
1975-76	7	9	3	19
1976-77	8	7	9	24
1977-78	8	9	11	28
1978-79	9	10	13	32

* Statistically, there was a significant decrease in carbon monoxide in 1973-74 and 1974-75.

** Includes stations where differences were less than 0.1 ppm to ensure changes are not due to monitoring instrument inaccuracies or other errors.

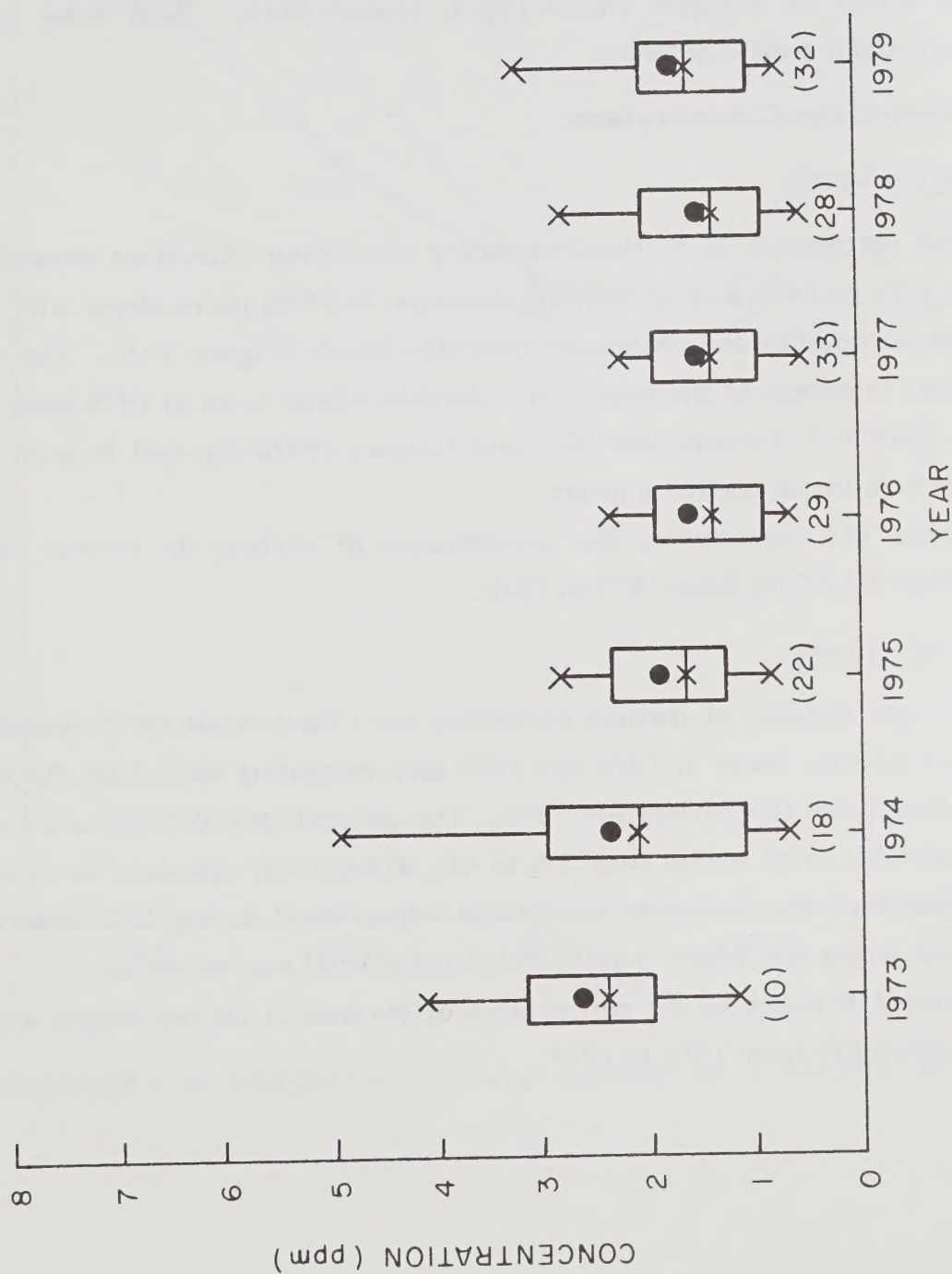


FIGURE 10 CARBON MONOXIDE - ANNUAL CONCENTRATION TRENDS IN CANADA (1973-79)

Trends in average CO annual means for all stations and Class I stations only are shown in Figure 11. As with other pollutants, the trend is similar for these two groups for the most recent years, and it can be concluded that Class I stations by themselves would provide a representative national sample of CO levels.

In 1979, Toronto commercial stations 60401C and 60416C reported the highest annual mean levels at 3.9 ppm and 5.0 ppm, respectively. Both sites are located downtown near major traffic arteries.

4.2 Short-Range Concentrations

8-Hour Maximum Levels

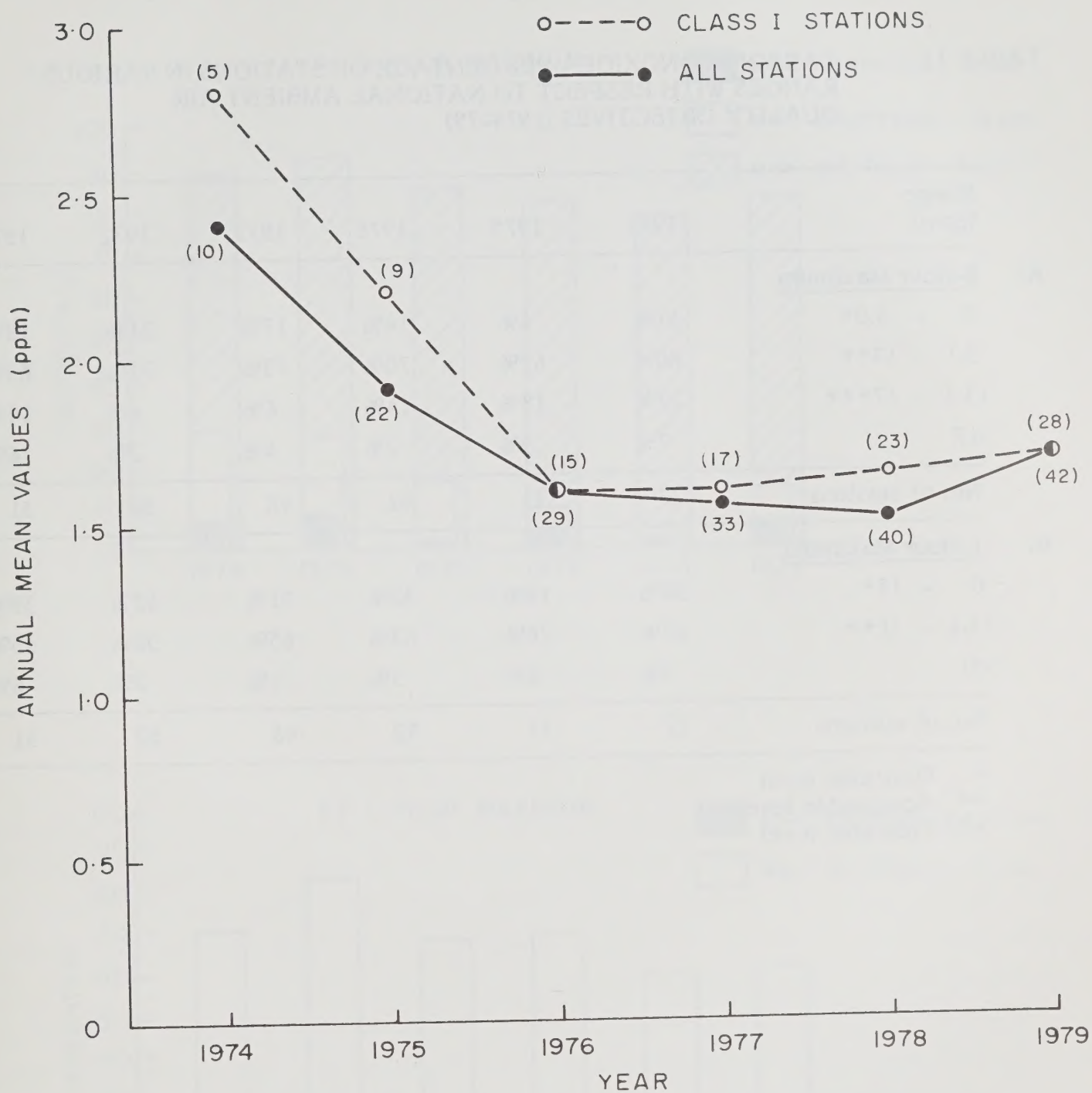
The percentage of stations exceeding the 8-hour objectives showed a general decline from 1974 to 1978, but an increase occurred in 1979, particularly with respect to the maximum acceptable and maximum tolerable levels (Figure 12A). The three sites reporting values in excess of the maximum tolerable 8-hour level in 1979 were located in Quebec City (50304C), Toronto (60416C) and Calgary (90227C), and in each case were near or adjacent to major traffic arteries.

Table 11A summarizes the percentages of stations in various ranges with respect to 8-hour NAAQO's from 1974 to 1979.

1-Hour Maximum Values

The percentages of stations exceeding the 1-hour maximum desirable CO level of 13 ppm were slightly lower in 1978 and 1979 (approximately 60%) than during each of the previous four years (approximately 70%). The percentages of stations exceeding the maximum acceptable level varied from 2% to 6%, without any apparent trend since 1974. Readings in excess of the maximum acceptable 1-hour level during 1979 occurred at the same three sites where the 8-hour maximum tolerable level was exceeded.

Table 11B indicates the percentages of stations in various ranges with respect to the 1-hour NAAQO's from 1974 to 1979.



NUMBERS IN BRACKETS INDICATE NUMBER OF STATIONS IN OPERATION.

FIGURE II TRENDS IN CO ANNUAL MEAN VALUES FOR ALL STATIONS AND CLASS I STATIONS (1974-79)

TABLE 11 CARBON MONOXIDE - PERCENTAGE OF STATIONS IN VARIOUS RANGES WITH RESPECT TO NATIONAL AMBIENT AIR QUALITY OBJECTIVES (1974-79)

Range (ppm)	1974	1975	1976	1977	1978	1979
A) 8-Hour Maximum						
0 - 5.0*	11%	6%	14%	17%	21%	18%
5.1 - 13**	60%	67%	70%	73%	71%	63%
13.1 - 17***	22%	18%	14%	6%	6%	14%
>17	7%	9%	2%	4%	2%	6%
No. of stations	27	33	42	48	52	51
B) 1-Hour Maximum						
0 - 13*	30%	18%	32%	31%	42%	39%
13.1 - 31**	67%	76%	63%	65%	56%	55%
>31	3%	6%	5%	4%	2%	6%
No. of stations	27	33	42	48	52	51

* Desirable level

** Acceptable level

*** Tolerable level

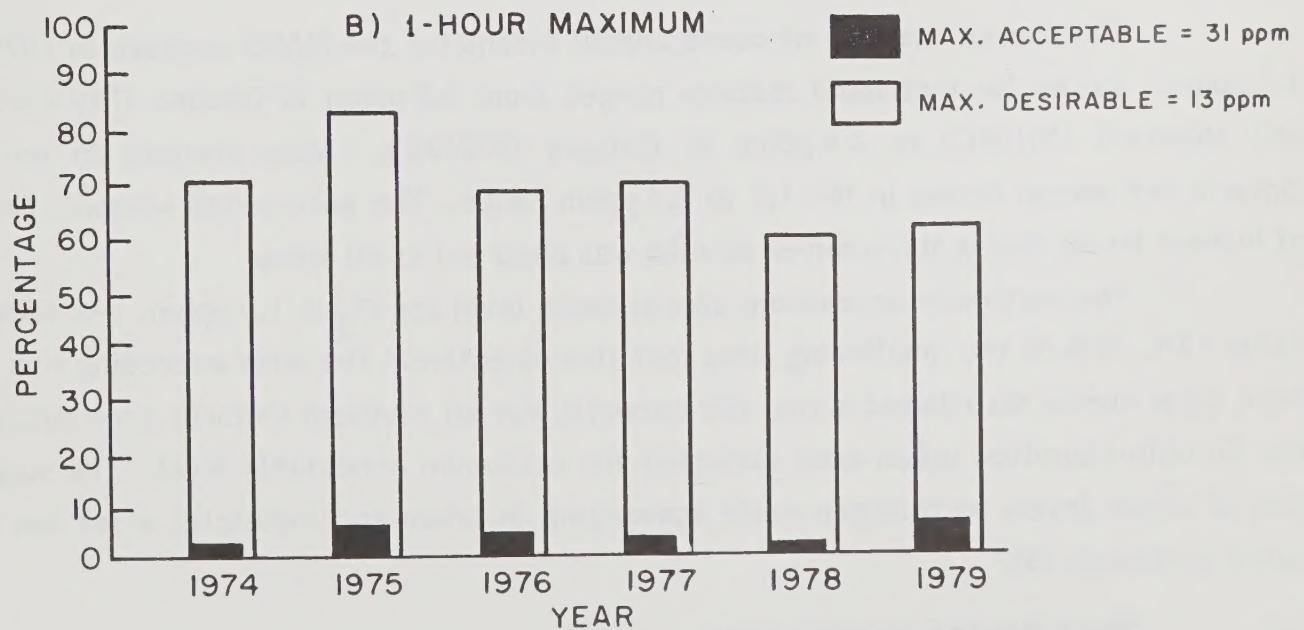
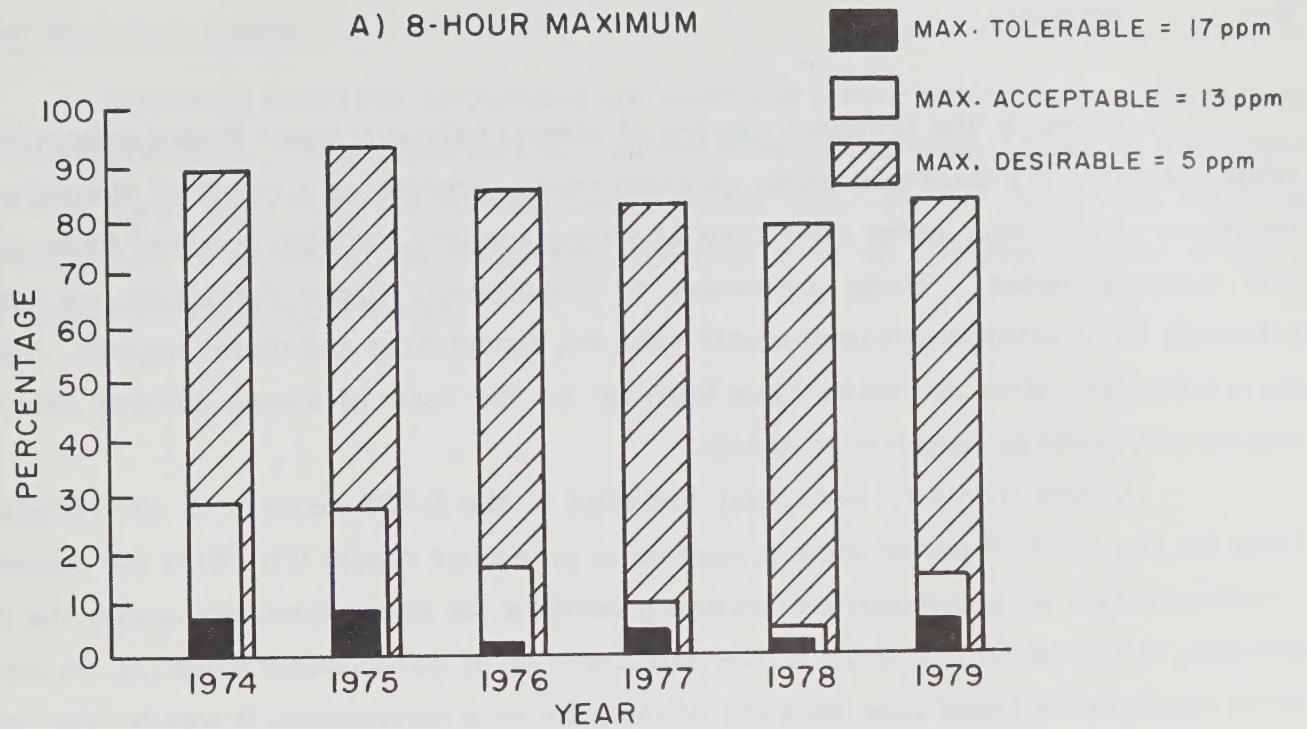


FIGURE 12 CARBON MONOXIDE - PERCENTAGE OF STATIONS EXCEEDING NAAQS'S (1974-79)

5 OZONE

Ozone is the principal species of several oxidizing gases known collectively as total oxidants. Atmospheric ozone concentrations increase as a result of photochemical reactions which occur under conditions of strong sunlight and high levels of hydrocarbons and nitrogen oxides. These precursors to atmospheric ozone formation are emitted primarily from gasoline-powered motor vehicles, forest fires and diesel engines. Ambient air quality objectives for ozone have been set on the basis of known adverse effects on vegetation, materials and human health.

Ozone monitors were first installed in the NAPS network in 1973 (Figure 1). Data for the 1973-74 period were presented in an earlier report (1). With the subsequent implementation of a common calibration procedure for ozone monitors across the NAPS network, it was found that some of the data could be of questionable value (2). In order to avoid assessments based upon data not suitable for intercomparison, it was decided to hold any interpretation of ozone data in abeyance until all questions of methodology were resolved. It is now believed that the ozone measurements made throughout the network in 1979 were reliable and consistent.

5.1 Annual Arithmetic Means

The overall average of ozone annual means for the NAPS network in 1979 was 1.5 ppm. Values for individual stations ranged from 0.8 ppm in Quebec City (50304C) and Montreal (50109C) to 2.4 ppm in Calgary (90222R). Most stations in southern Ontario had annual means in the 1.7 to 2.3 ppm range. The anticipated seasonal pattern of highest levels during the summer months was observed at all sites.

The maximum acceptable annual mean level for O_3 is 1.5 ppm. As shown in Table 12A, 50% of the monitoring sites met this objective. The sites exceeding this level were quite evenly distributed across the network, but all southern Ontario sites outside of the Toronto-Hamilton urban area exceeded the maximum acceptable level. The suppression of ozone levels by nitrogen oxide scavenging in urban and industrial areas has been noted previously (8).

5.2 Short-Range Concentrations

24-Hour Maximum Levels

All stations reported 24-hour average values in excess of the maximum acceptable level of 3 ppm. Such values occurred quite regularly during the summer months at many of the stations, such as those in southwestern Ontario.

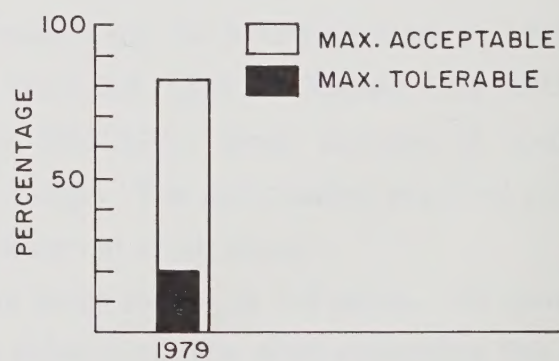
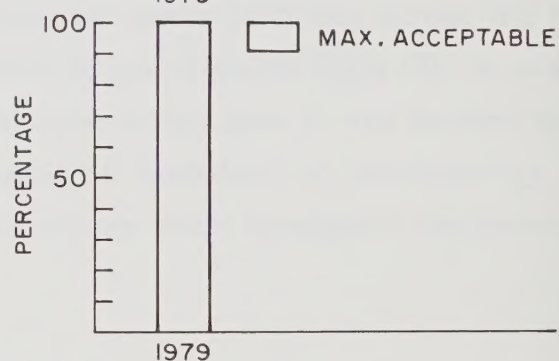
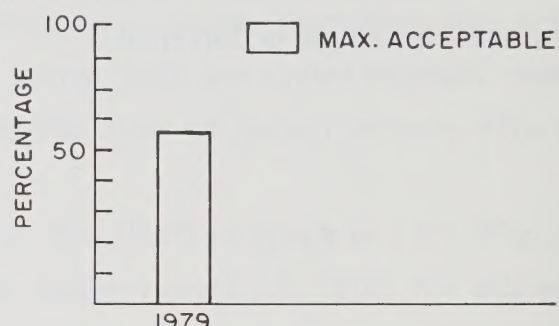
1-Hour Maximum Levels

Maximum desirable, acceptable and tolerable 1-hour mean O_3 levels have been established (Table 1). The percentages of stations showing maximum values in the ranges defined by these objectives are summarized in Table 12C. Twenty percent of the sites reported values in excess of the maximum tolerable level of 15 pphm. These were, in most instances, single occurrences.

TABLE 12 OZONE - PERCENTAGE OF STATIONS IN VARIOUS RANGES WITH RESPECT TO NATIONAL AMBIENT AIR QUALITY OBJECTIVES (1979)

	Range (pphm)	1979
A) Annual Means		
	0 - 1.5**	50%
	No. of stations	38
B) 24-Hour Maximum		
	0 - 2*	
	2.1 - 3**	
	>3	100%
	No. of stations	44
C) 1-Hour Maximum		
	0 - 5*	2%
	5.1 - 8**	16%
	8.1 - 15***	62%
	>15	20%
	No. of stations	45

* Maximum desirable
 ** Maximum acceptable
 *** Maximum tolerable



6 SUSPENDED PARTICULATES

Suspended particulates (SP) is a general term applied to a wide variety of solid or liquid particles of a size and configuration such that they tend to remain airborne and thus can be drawn into the respiratory system. Particulate matter is the most commonly perceived form of air pollution, often manifesting itself by its impairment of visibility, its soiling effect on materials and its irritation of the respiratory system. Ambient air quality objectives have been established with the goal of minimizing these undesirable effects. The Air Pollution Control Directorate recently initiated a monitoring program designed to obtain information on particle size distributions and chemical composition of particulate matter in six Canadian cities in order to increase understanding of this contaminant. It has also undertaken to improve the particulate emissions inventory by determining the particle size and chemical composition of the most important contributing sectors of such emissions in Canada.

Forest fires, iron ore mining and beneficiation, mining and rock quarrying, sulphate (kraft) pulping, power plants, slash burning, and cement manufacturing are all important sources of suspended particulate matter.

6.1 Annual Geometric Means

The overall average of the annual geometric means decreased approximately 18% between 1970 and 1975, and mean values appear to have levelled off in the 60-70 $\mu\text{g}/\text{m}^3$ range in recent years (Figure 13 and Appendix I). The decrease in average levels has been largely the consequence of improved conditions at the dirtier stations. When statistical analysis was applied to determine whether the change in any two consecutive years was significant, SP levels were found to have decreased significantly in 1970-71, 1971-72, 1974-75 and 1976-77 (Table 3). There were significant increases in 1972-73 and 1978-79. The increase in 1978-79 appears to have been due to an increase in concentrations at the dirtier stations. The number of stations indicating changes in annual geometric means from 1970 to 1979 are summarized in Table 13.

Trends in average annual mean values for all stations and Class I stations only for the 1974-79 period are shown in Figure 14. While the general trends indicated by the two sets of stations are similar, the absolute values shown by the Class I stations were significantly higher in 1974 and 1975. For more recent years, the agreement is much improved and it appears that Class I stations alone do provide a representative sample of generally prevailing SP levels.

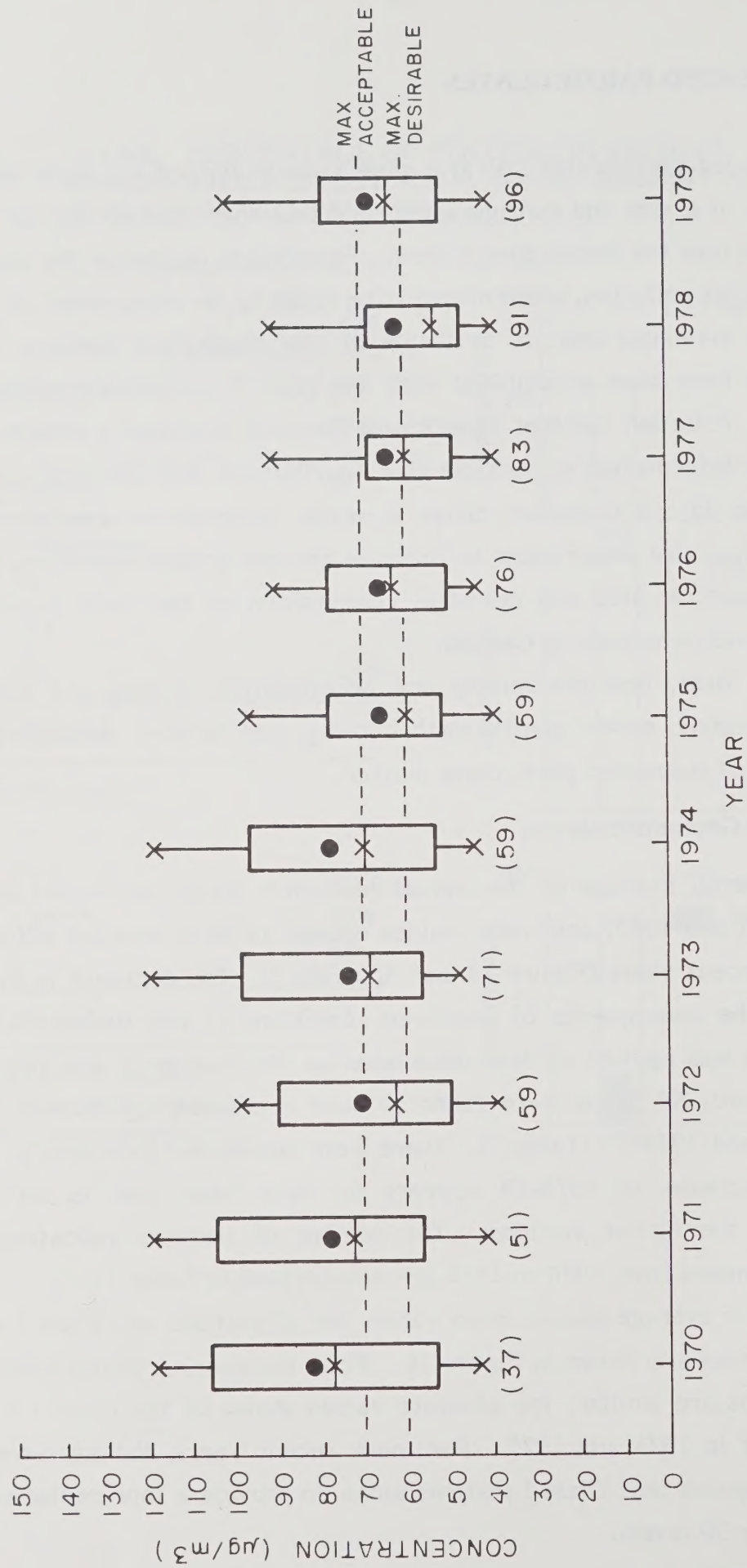
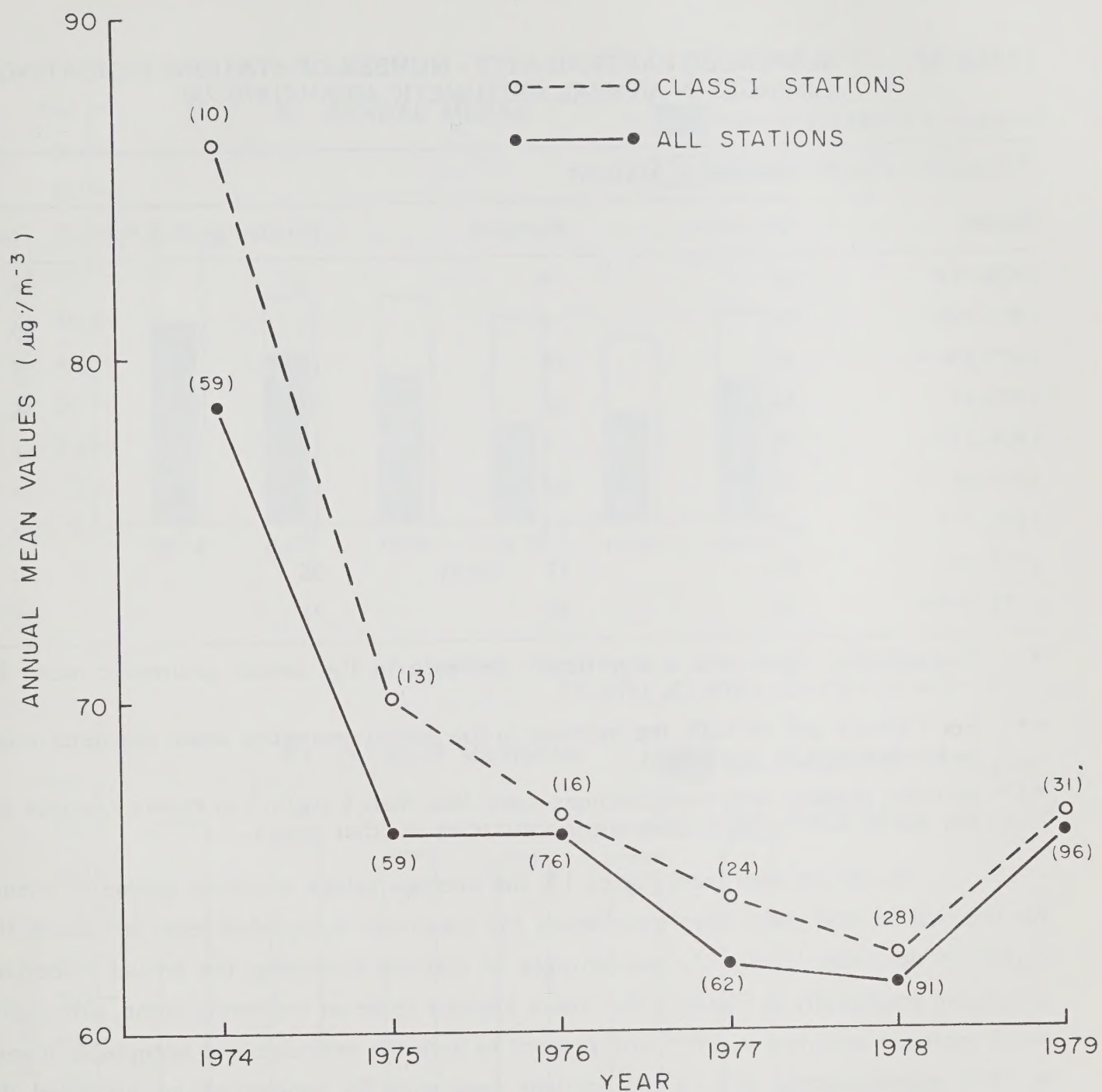


FIGURE 13 SUSPENDED PARTICULATES - ANNUAL CONCENTRATION TRENDS IN CANADA
(1970 - 79)



NUMBERS IN BRACKETS INDICATE NUMBER OF STATIONS IN OPERATION.

FIGURE 14 TRENDS IN SUSPENDED PARTICULATE ANNUAL MEAN VALUES FOR ALL STATIONS AND CLASS I STATIONS (1974 - 79)

TABLE 13 SUSPENDED PARTICULATES - NUMBER OF STATIONS INDICATING
CHANGES IN ANNUAL ARITHMETIC MEAN (1970-79)

Period	Number of Stations			Total
	Decrease	Increase	No change * * *	
1970-71*	23	5	8	36
1971-72*	26	8	11	45
1972-73**	10	26	19	55
1973-74	16	16	24	56
1974-75*	30	9	12	51
1975-76	14	17	23	54
1976-77*	23	13	31	67
1977-78	26	12	36	74
1978-79**	14	40	31	85

* Statistically, there was a significant decrease in the annual geometric mean for 1970-71, 1971-72, 1974-75, 1976-77.

** For 1972-73 and 1978-79, the increase in the annual geometric mean was determined to be statistically significant.

*** Includes stations where differences were less than $4 \mu\text{g}/\text{m}^3$ to ensure changes are not due to monitoring instrument inaccuracies or other errors.

As can be seen from Figure 13, the average values of annual geometric means for the past several years have been below the maximum acceptable level but above the maximum desirable level. The percentages of stations exceeding the annual objectives are shown graphically in Figure 15A. There appears to be an improving trend, although a small increase occurred in 1979 with respect to both the desirable and acceptable levels. In 1979, approximately 34% of the stations measuring SP concentrations exceeded the maximum acceptable level of $70 \mu\text{g}/\text{m}^3$, compared with approximately 50% in 1974. Similarly, the percentage of stations exceeding the maximum desirable level of $60 \mu\text{g}/\text{m}^3$ decreased from 70% in 1974 to approximately 50% in 1979. The percentages of stations reporting annual geometric means in the various ranges defined by the NAAQO's are summarized in Table 14A.

Stations reporting the highest annual geometric means in 1979 were:

- Sydney, N.S. (30311R) at $146 \mu\text{g}/\text{m}^3$, with a steel mill and coke oven complex the predominant local source of particulate matter;

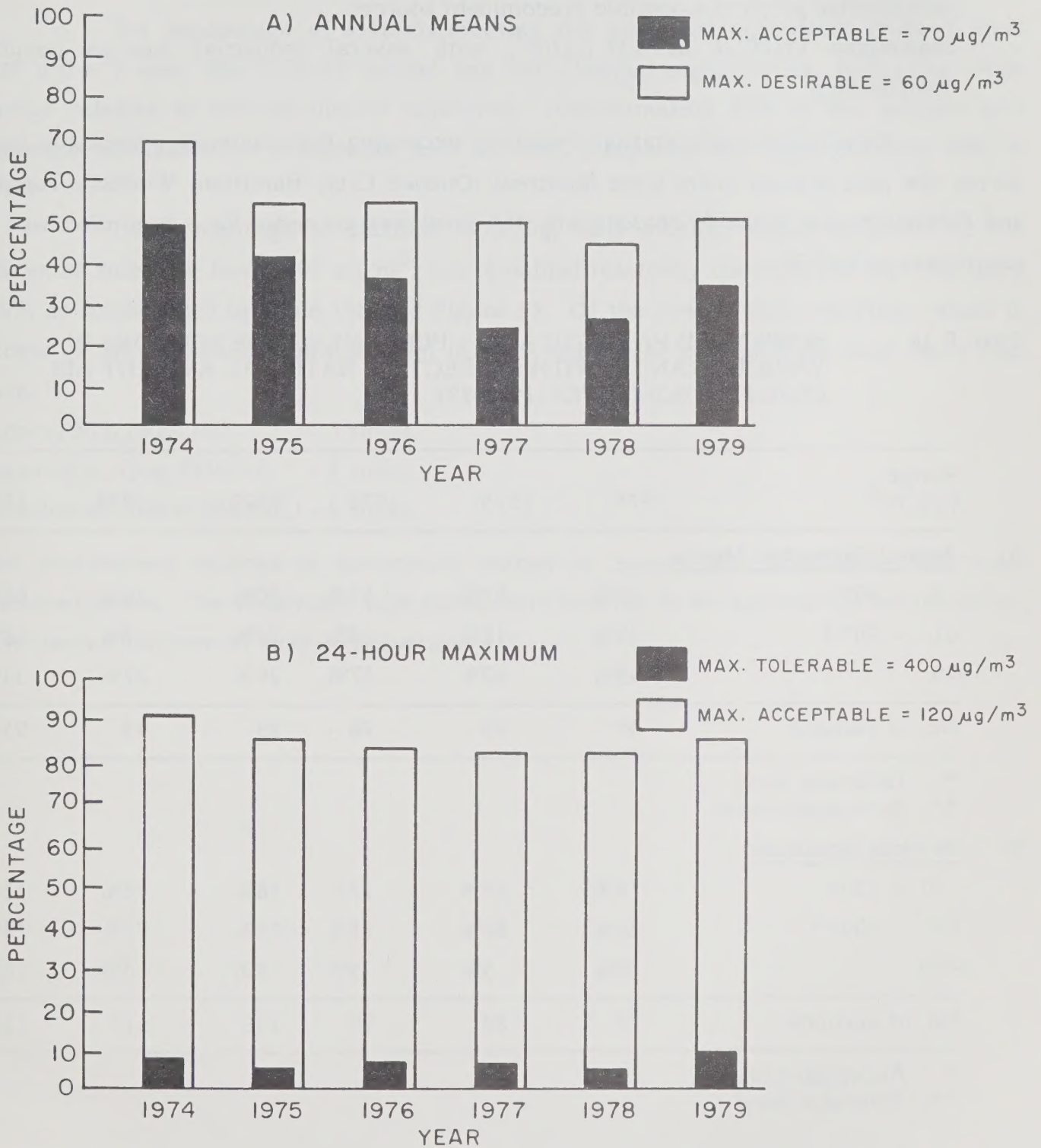


FIGURE 15 SUSPENDED PARTICULATES - PERCENTAGE OF STATIONS EXCEEDING NAAQO'S (1974-79)

- Calgary (90218I) at 139 $\mu\text{g}/\text{m}^3$, with re-entrained dust from unpaved roadways and construction projects a possible predominant source;
- Shawinigan (51201I) at 137 $\mu\text{g}/\text{m}^3$, with several industrial sources possible contributors.

Other cities with stations regularly exceeding the maximum acceptable level during the past several years were Montreal, Quebec City, Hamilton, Windsor, Toronto and Edmonton; the probable reasons why the level was exceeded have been discussed in previous reports (1,2).

TABLE 14 SUSPENDED PARTICULATES - PERCENTAGE OF STATIONS IN
VARIOUS RANGES WITH RESPECT TO NATIONAL AMBIENT AIR
QUALITY OBJECTIVES (1974-79)

Range ($\mu\text{g}/\text{m}^3$)	1974	1975	1976	1977	1978	1979
A) Annual Geometric Means						
0 - 60*	32%	47%	45%	50%	56%	48%
61 - 70**	19%	11%	18%	26%	17%	18%
>70	49%	42%	37%	24%	27%	34%
No. of stations	59	60	76	83	95	95
* Desirable level						
** Acceptable level						
B) 24-Hour Maximum						
0 - 120*	6%	15%	17%	18%	18%	11%
121 - 400**	86%	80%	75%	74%	77%	78%
>400	8%	5%	8%	8%	5%	10%
No. of stations	72	82	99	106	117	116
* Acceptable level						
** Tolerable level						

6.2 Short-Range Concentrations

The percentage of stations meeting the maximum acceptable 24-hour level ($120 \mu\text{g}/\text{m}^3$) over the 1974-79 period has not changed significantly, indicating little change relative to this air quality objective. Approximately 85% of the stations still exceeded the maximum acceptable level in 1979, compared with approximately 90% in 1974.

The percentage of stations reporting daily average values in excess of the maximum tolerable level ($400 \mu\text{g}/\text{m}^3$) has remained relatively constant (5% to 10%) since 1974, as summarized in Table 14B and Figure 15. Of the twelve sites reporting values in excess of the maximum tolerable level in 1979, only three exceeded the level more than once:

Sydney, N.S. (30311R) - 5 times

Shawinigan, Que. (51201I) - 6 times

Whitehorse, Yukon (09001C) - 4 times

The predominant sources of particulate matter in Sydney and Shawinigan have been discussed above. The abnormally high particulate loadings in Whitehorse can be attributed to an unusual amount of road construction.

7 LEAD

Lead levels in ambient air are of concern with respect to human health. Gasoline-powered motor vehicles are the major source of lead emissions into the atmosphere. They account for more than 70% of total airborne lead emissions in Canada. Other sources include the primary production of copper and nickel, and the operations involved in lead mining, milling, smelting and refining.

Lead in ambient air is present as a component of suspended particulates and is determined by analyzing the samples collected for suspended particulate determinations.

7.1 Annual Geometric Means

The average of annual mean lead levels decreased approximately 45% between 1970 and 1979 (See Appendix I and Figure 16). During this period, the poorer stations showed a consistent improvement as indicated by the upper 10 percentile figures. Statistical tests to determine if the change between any two consecutive years was significant showed that annual lead levels decreased significantly in all years except from 1971 to 1972 and 1972 to 1973, for which periods there was no indication of a trend (Table 3). The number of stations indicating changes in annual geometric means are listed in Table 15.

Trends in average annual mean lead levels measured at Class I stations and at all stations in the NAPS network are shown in Figure 17. Class I stations show significantly higher levels than do other stations, consistent with the fact that Class I sites are exclusively in downtown urban areas where lead levels can be expected to be higher than average. The data indicate a convergence of the average levels measured by the two sets of stations, but the Class I average continued to be approximately 20% higher than the overall average in 1978 and 1979. The convergence of values can be expected to continue as the automobile population is gradually converted to the use of non-leaded gasoline.

The Montreal station at Duncan and Decarie (50109C), located close to an autoroute interchange, has shown the highest lead levels in the NAPS network since 1974 (2). These high levels continued during 1978 and 1979, with an annual mean value of $1.4 \mu\text{g}/\text{m}^3$ reported in both 1978 and 1979. Other stations reporting high lead levels in these years were the residential station at Bathurst and Wilson (60412R) in Toronto ($1.1 \mu\text{g}/\text{m}^3$), the industrial station at Evans and Arnold (60403I) in Toronto ($1.2 \mu\text{g}/\text{m}^3$),

TABLE 15 LEAD - NUMBER OF STATIONS INDICATING CHANGES IN ANNUAL GEOMETRIC MEAN (1970-79)

Period	Number of Stations			Total
	Decrease	Increase	No change **	
1970-71*	23	2	4	29
1971-72	17	9	9	35
1972-73	20	17	15	52
1973-74*	28	8	19	55
1974-75*	23	3	23	49
1975-76*	19	3	20	42
1976-77*	18	3	26	47
1977-78*	30	7	18	55
1978-79*	28	6	22	56

* The Wilcoxon test indicates that lead levels decreased significantly during 1970-71 and throughout the 1973-79 period.

** Includes stations where differences were less than $0.04 \mu\text{g}/\text{m}^3$ to ensure changes are not due to monitoring instrument inaccuracies or other errors.

and the commercial station at Peel and Maisonneuve (50115C) in Montreal ($1.5 \mu\text{g}/\text{m}^3$ in 1978). All of these stations are located in the vicinity of major thoroughways or busy city streets and hence are affected by the major source of lead emissions - the gasoline-powered motor vehicle.

7.2 Short-Range Concentrations

24-Hour Maximum Levels

No ambient air quality objectives have been established for lead (6). However, a comparison of the national averages of the 24-hour maxima for recent years gives some indication of the decreasing trend in maximum lead levels at the NAPS monitoring sites:

Year	$\mu\text{g}/\text{m}^3$
1974	3.0
1975	2.5
1976	2.0
1977	2.1
1978	1.8
1979	1.6

This downward trend in maximum values parallels the pattern in mean values shown in Figure 17.

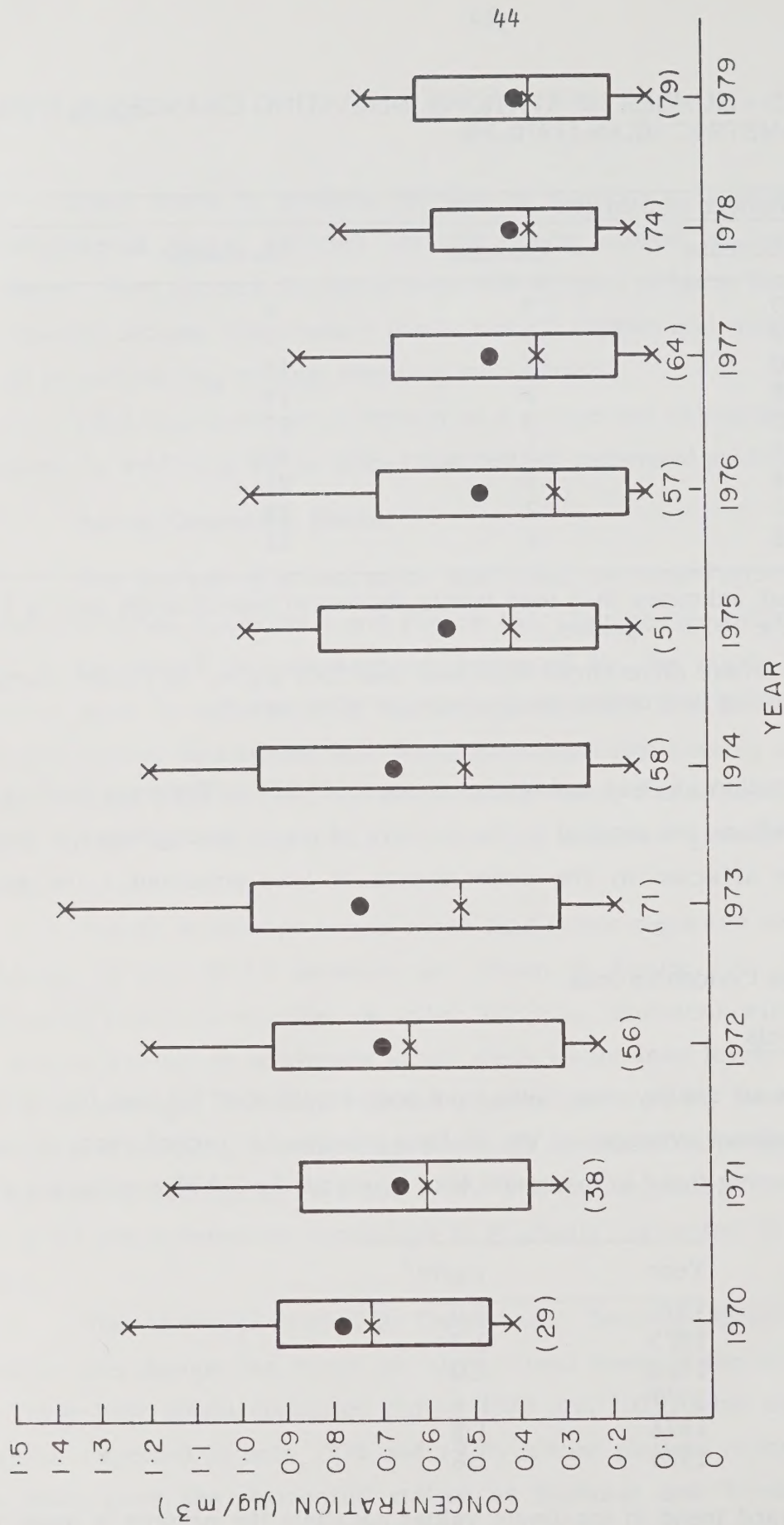
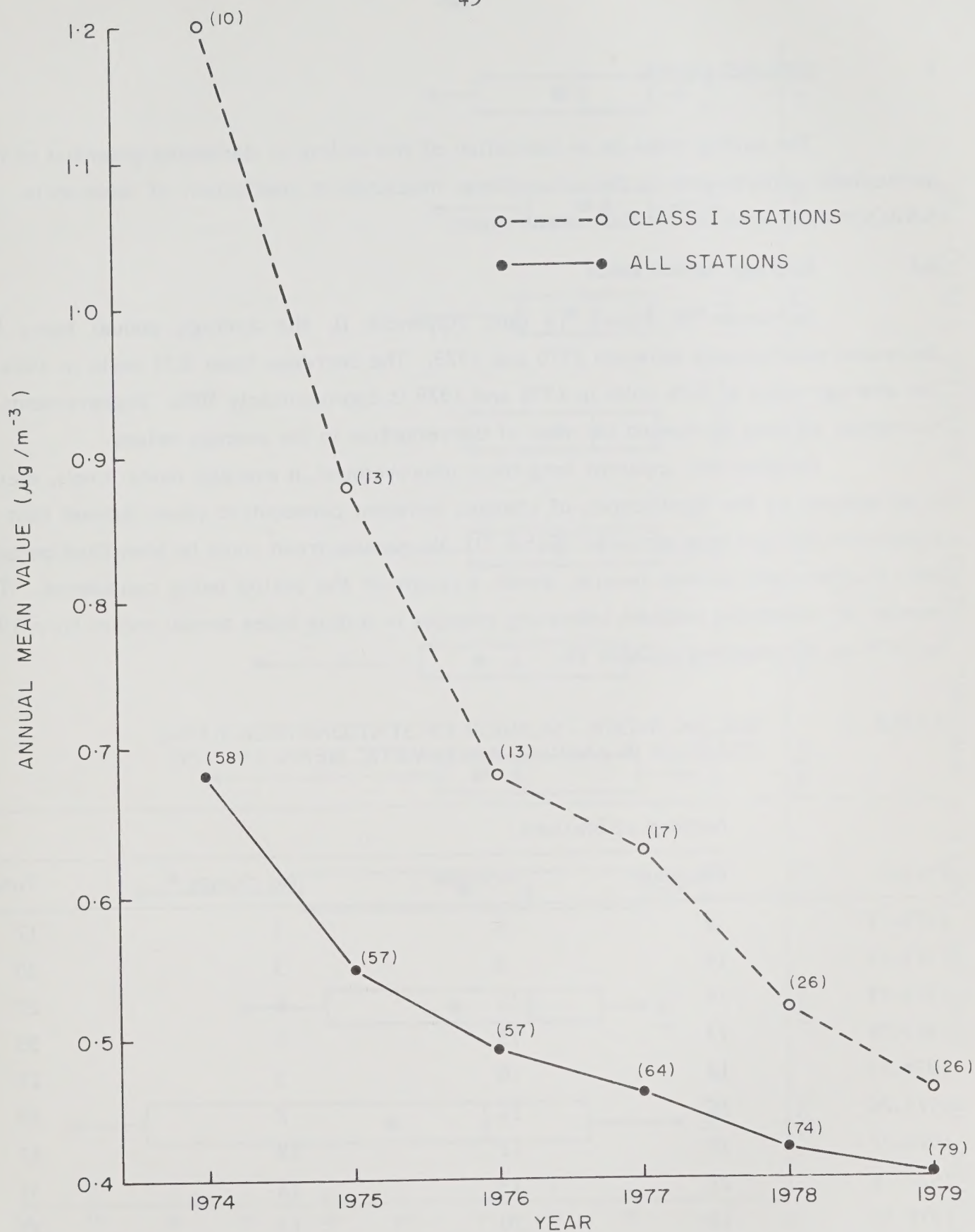


FIGURE 16 LEAD - ANNUAL CONCENTRATION TRENDS IN CANADA (1970 -79)



NUMBERS IN BRACKETS INDICATE NUMBER OF STATIONS IN OPERATION

FIGURE 17 TRENDS IN LEAD ANNUAL MEAN VALUES FOR ALL STATIONS AND CLASS I STATIONS (1974 - 79)

8 SOILING INDEX

The soiling index is an indication of the soiling or darkening potential of fine particulate contaminants in the atmosphere, measured in coefficient of haze units. No NAAQO's have been set for this measurement.

8.1 Average Annual Index

As shown in Figure 18 (and Appendix I), the average annual index has decreased substantially between 1970 and 1979. The decrease from 0.51 units in 1974 to the average value of 0.26 units in 1978 and 1979 is approximately 50%. Improvements at the dirtier stations accounted for most of the reduction in the average values.

Despite this apparent long-term improvement in average index levels, statistical analysis of the significance of changes between consecutive years showed that no significant changes have occurred (Table 3). No general trend could be identified because individual stations showed reverse trends throughout the period being considered. The number of monitoring stations indicating changes in soiling index annual means from 1970 to 1979 are summarized in Table 16.

TABLE 16 SOILING INDEX - NUMBER OF STATIONS INDICATING CHANGES IN ANNUAL ARITHMETIC MEAN (1970-79)

Period	Number of Stations			Total
	Decrease	Increase	No change *	
1970-71	8	6	3	17
1971-72	19	8	3	30
1972-73	10	11	6	27
1973-74	13	13	7	33
1974-75	12	10	5	27
1975-76	16	16	7	39
1976-77	16	12	19	47
1977-78	21	13	18	52
1978-79	18	20	15	53

* Includes stations indicating differences of less than 0.01 COH units to ensure changes are not due to monitoring instrument inaccuracies or other errors.

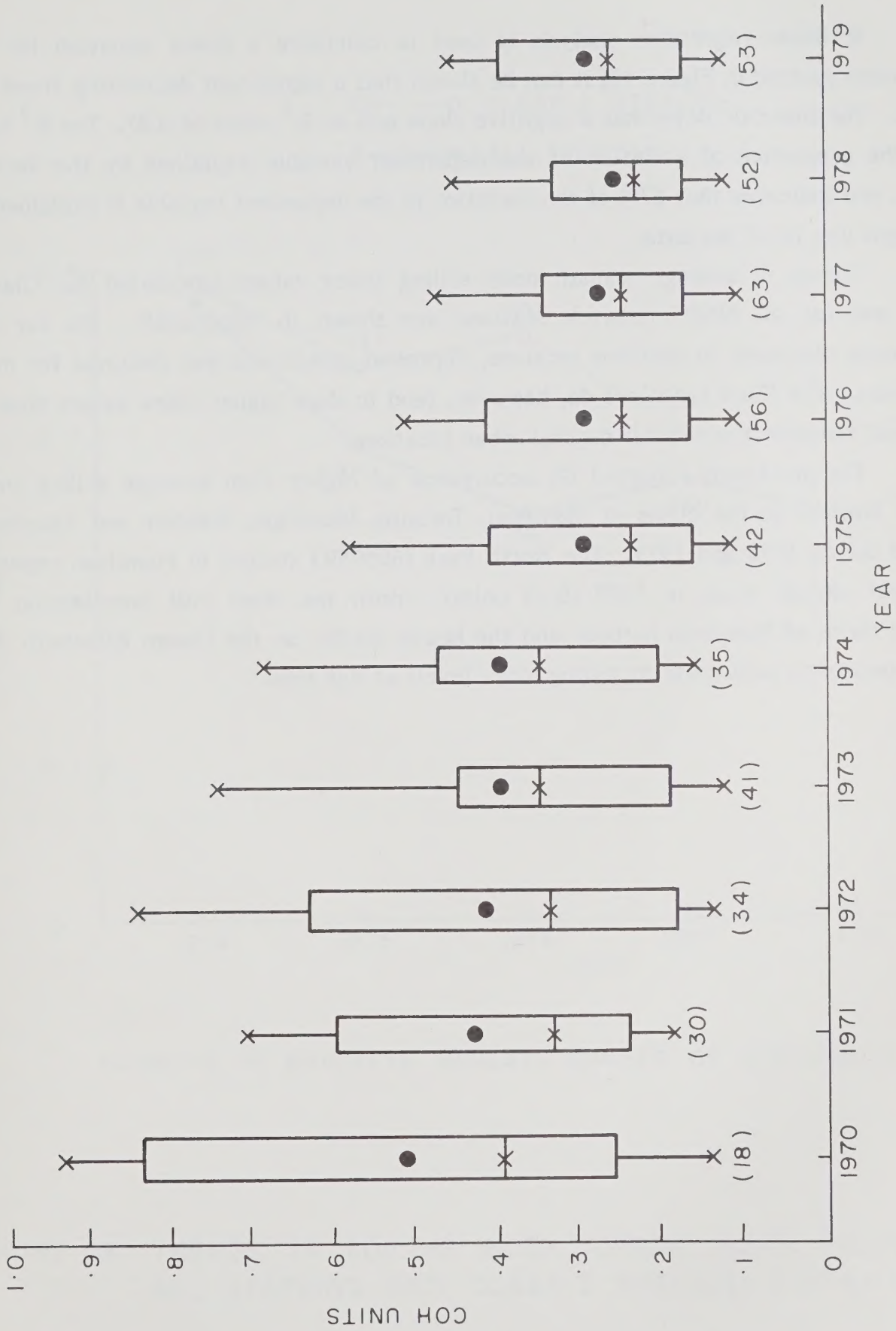
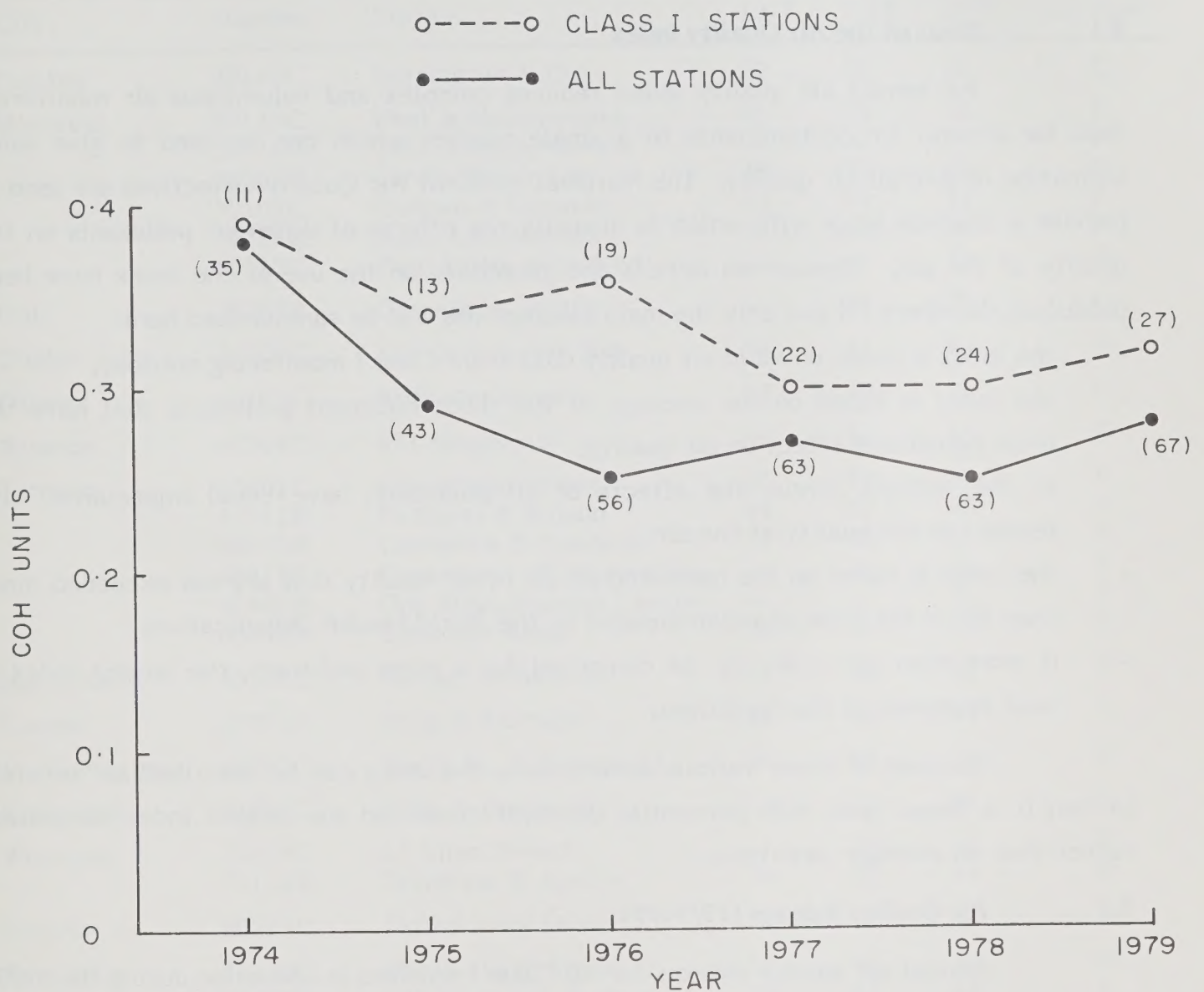


FIGURE 18 SOILING INDEX - ANNUAL TRENDS IN CANADA (1970-79)

If linear regression analysis is used to calculate a linear equation for the annual means plotted in Figure 18, it can be shown that a significant decreasing trend has occurred. The line calculated has a negative slope and an R^2 value of 0.87. The R^2 term defines the proportion of variation of the dependent variable explained by the derived equation, and indicates that 87% of the variation in the dependent variable is explained by the straight line fit of the data.

Trends in average annual mean soiling index values calculated for Class I stations and for all NAPS network stations are shown in Figure 19. As for the contaminants discussed in previous sections, improved agreement was obtained for more recent years. The Class I stations do, however, tend to show higher index values than do all stations, consistent with their central urban locations.

The previously reported (2) occurrence of higher than average soiling index values in stations in the cities of Montreal, Toronto, Hamilton, Windsor and Vancouver continued during 1978 and 1979. The North Park (60505R) station in Hamilton reported the highest annual mean in 1979 (0.73 units). Both the steel mill complex on the southwest shore of Hamilton harbour and the heavy traffic on the Queen Elizabeth Way can be expected to contribute to soiling index levels at this site.



NUMBERS IN BRACKETS INDICATE NUMBER OF STATIONS IN OPERATION

FIGURE 19 TRENDS IN SOILING INDEX ANNUAL MEAN VALUES FOR ALL STATIONS AND CLASS I STATIONS (1974 - 79)

9 ANNUAL AIR QUALITY INDEX

9.1 Basis of the Air Quality Index

An annual air quality index reduces complex and voluminous air monitoring data for several air contaminants to a single number which can be used to give some indication of overall air quality. The National Ambient Air Quality Objectives are used to provide a common scale with which to quantify the effects of different pollutants on the quality of the air. Conceptual details and guidelines on the use of the index have been published elsewhere (5) and only the main assumptions will be summarized here:

- the index is based on valid air quality data from Class I monitoring stations;
- the index is based on the average of the three different pollutants that have the most significant effect on air quality;
- at the defined levels, the effects of all pollutants have equal importance with respect to the quality of the air;
- the index is based on the measured levels of air quality that are not exceeded more than 2% of the time as recommended by the World Health Organization;
- if more than one index can be computed for a given pollutant, the largest index is used to represent that pollutant.

Because of these various assumptions, the index can be described as "severe", in that it is based upon 98th percentile concentrations and the largest index computed, rather than on average conditions.

9.2 Air Quality Indexes (1977-79)

Annual air quality indexes for all Class I stations in operation during the 1977-79 period were calculated in accordance with the guidelines in the published report. The calculated values are summarized in Table 17 and a qualitative descriptor (Good, 0-25; Fair, 30-50; and Poor, 50+) was assigned to each station on the basis of the three-year period. Individual stations do not show large year-to-year variations and it is probably premature to attempt to quantitatively assess such trends.

The majority of the sites may be categorized as "Fair". Three sites showed an index of less than 25 on at least one of the three years and accordingly could be classified as "Good". Five sites have shown indexes greater than 50 in at least one of the years, and the air quality at each could be categorized as "Poor". These five stations are all commercial sites under the influence of heavy vehicular traffic.

TABLE 17 INDEX OF AIR QUALITY FOR CLASS I STATIONS (1977-79)

City	Number	Station	1977	1978	1979	Category
Halifax	30116C	Barrington & Duke	22	22	26	G
Montreal	50115C	Peel & Maisonneuve	45	50	46	F
	50116R	3161 Joseph, Verdun	--	--	39	F
	50102R	Jardin Botanique	39	37	34	F
	50109C	Duncan & Decarie	43	49	51	P
	50112C	Boul. Laurentides	--	35	30	F
	50110C	Parc Pilon, Mtl-Nord	--	--	31	F
Hull	50203R	Gamelin & Joffre	--	20	28	G
Quebec City	50304C	155 Dorchester Sud	58	47	47	P
Ottawa	60101C	88 Slater Street	42	39	38	F
Windsor	60204C	471 University	46	46	33	F
Toronto	60401C	67 College Street	40	43	44	F
	60412R	Bathurst & Wilson	44	42	45	F
	60410R	Lawrence & Kennedy	37	40	40	F
	60415R	Queensway W. Hurontario	--	40	40	F
	60402R	Don Mills, Science Centre	--	--	31	F
	60413R	Elmcrest Road	36	41	34	F
Hamilton	60501C	Barton & Sanford	51	51	48	P
London	60901C	King & Rectory	44	42	44	F
St. Catharines	61301C	North St. & Geneva St.	46	42	38	F
Kitchener	61501C	Edna & Frederick	41	47	41	F
Winnipeg	70119C	65 Ellen Street	--	39	40	F
	70118R	Jefferson & Scotia	34	28	44	F
Regina	80109C	1620 Albert Street	--	--	40	F
Edmonton	90130C	10255-104th Street	48	48	53	P
	90122R	127 St. & 133 Avenue	39	41	45	F
Calgary	90227C	1611-4th Street S.W.	48	49	56	P
	90222R	39 St. & 29 Ave. N.W.	36	35	37	F
Vancouver	00112C	Robson & Hornby	36	32	37	F
	00106R	2294 West 10th Avenue	36	34	40	F
	00108I	250 West 70th Avenue	40	36	42	F
	00110R	E. Hastings & Kensington	33	36	36	F
	00111I	Rocky Pt. Park	--	26	32	F
Victoria	00302C	1106 Cook Street	29	23	23	G

Index	Category
0 - 25	Good
26 - 50	Fair
51 - 100	Poor
100+	Very Poor

ACKNOWLEDGEMENT

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APPENDIX I

SUMMARY DATA - URBAN AIR QUALITY TRENDS IN CANADA, 1970-79

SUMMARY DATA -- URBAN AIR QUALITY TRENDS IN CANADA, 1970-79

Pollutant	Year	Number of Sites	Average of Annual Mean	Percentage of Sites with Annual Mean Cleaner than Given Values				
				90%	75%	50%	25%	10%
SO ₂ (pphm)	1972	34	2.1	3.7	2.9	1.6	1.0	< 1.0
	1973	39	1.6	3.2	1.9	< 1.0	< 1.0	< 1.0
	1974	27	1.6	2.6	2.2	1.2	< 1.0	< 1.0
	1975	36	1.5	2.3	1.9	1.1	< 1.0	< 1.0
	1976	48	1.4	2.4	2.0	1.1	< 1.0	< 1.0
	1977	59	1.4	2.3	1.5	< 1.0	< 1.0	< 1.0
	1978	71	1.3	2.0	1.3	< 1.0	< 1.0	< 1.0
	1979	69	1.2	1.8	1.3	< 1.0	< 1.0	< 1.0
NO ₂ (pphm)	1977	27	3.1	4.4	3.9	2.7	2.1	1.9
	1978	33	2.9	4.0	3.5	2.9	2.0	1.8
	1979	34	2.6	3.4	3.1	2.7	1.9	1.2
CO (ppm)	1973	10	2.7	4.3	3.3	2.5	2.1	1.1
	1974	18	2.4	5.0	3.0	2.2	1.2	0.7
	1975	22	1.9	2.8	2.4	1.7	1.3	0.8
	1976	29	1.6	2.4	1.9	1.4	0.9	0.7
	1977	33	1.6	2.3	1.9	1.4	0.9	0.5
	1978	40	1.5	2.8	2.0	1.3	0.8	0.5
	1979	42	1.7	3.2	2.0	1.5	1.0	0.8
Ozone (pphm)	1979	39	1.5	2.0	1.8	1.5	1.2	1.0
SP (µg/m ³)	1970	37	81.9	118.0	106.0	77.0	53.0	43.0
	1971	51	78.6	121.0	104.0	73.0	56.0	41.0
	1972	59	70.4	99.0	90.0	62.0	50.0	38.0
	1973	71	74.8	121.0	97.0	69.0	57.0	47.0
	1974	59	78.6	121.0	96.0	70.0	53.0	43.0
	1975	59	65.9	98.0	77.0	61.0	51.0	39.0
	1976	76	65.7	91.0	78.0	64.0	50.0	43.0
	1977	83	61.9	93.0	69.0	61.0	48.0	39.0
	1978	91	61.4	92.0	68.0	53.0	44.0	36.0
	1979	96	66.0	99.0	78.0	60.0	50.0	38.0

SUMMARY DATA - - URBAN AIR QUALITY TRENDS IN CANADA, 1970-79 (continued)

Pollutant	Year	Number of Sites	Average of Annual Mean	Percentage of Sites with Annual Mean Cleaner than Given Values				
				90%	75%	50%	25%	10%
Lead ($\mu\text{g}/\text{m}^3$)	1970	29	0.79	1.28	0.94	0.74	0.48	0.43
	1971	38	0.67	1.18	0.89	0.61	0.39	0.31
	1972	56	0.70	1.22	0.94	0.65	0.31	0.23
	1973	71	0.74	1.40	0.98	0.54	0.31	0.18
	1974	58	0.68	1.22	0.97	0.53	0.26	0.15
	1975	57	0.55	1.00	0.83	0.41	0.23	0.15
	1976	57	0.49	1.00	0.70	0.32	0.17	0.11
	1977	64	0.46	0.89	0.67	0.36	0.19	0.10
	1978	74	0.42	0.75	0.57	0.36	0.23	0.14
	1979	79	0.39	0.72	0.55	0.36	0.21	0.12
Soiling Index (COH)	1970	18	0.51	0.94	0.83	0.39	0.26	0.13
	1971	30	0.43	0.71	0.60	0.34	0.24	0.18
	1972	34	0.42	0.85	0.63	0.34	0.18	0.13
	1973	41	0.40	0.74	0.45	0.35	0.19	0.12
	1974	35	0.38	0.67	0.46	0.34	0.20	0.14
	1975	42	0.28	0.56	0.40	0.23	0.16	0.11
	1976	56	0.28	0.49	0.40	0.24	0.16	0.10
	1977	63	0.27	0.47	0.33	0.24	0.17	0.10
	1978	63	0.25	0.44	0.32	0.22	0.17	0.11
	1979	67	0.28	0.45	0.39	0.26	0.18	0.15

